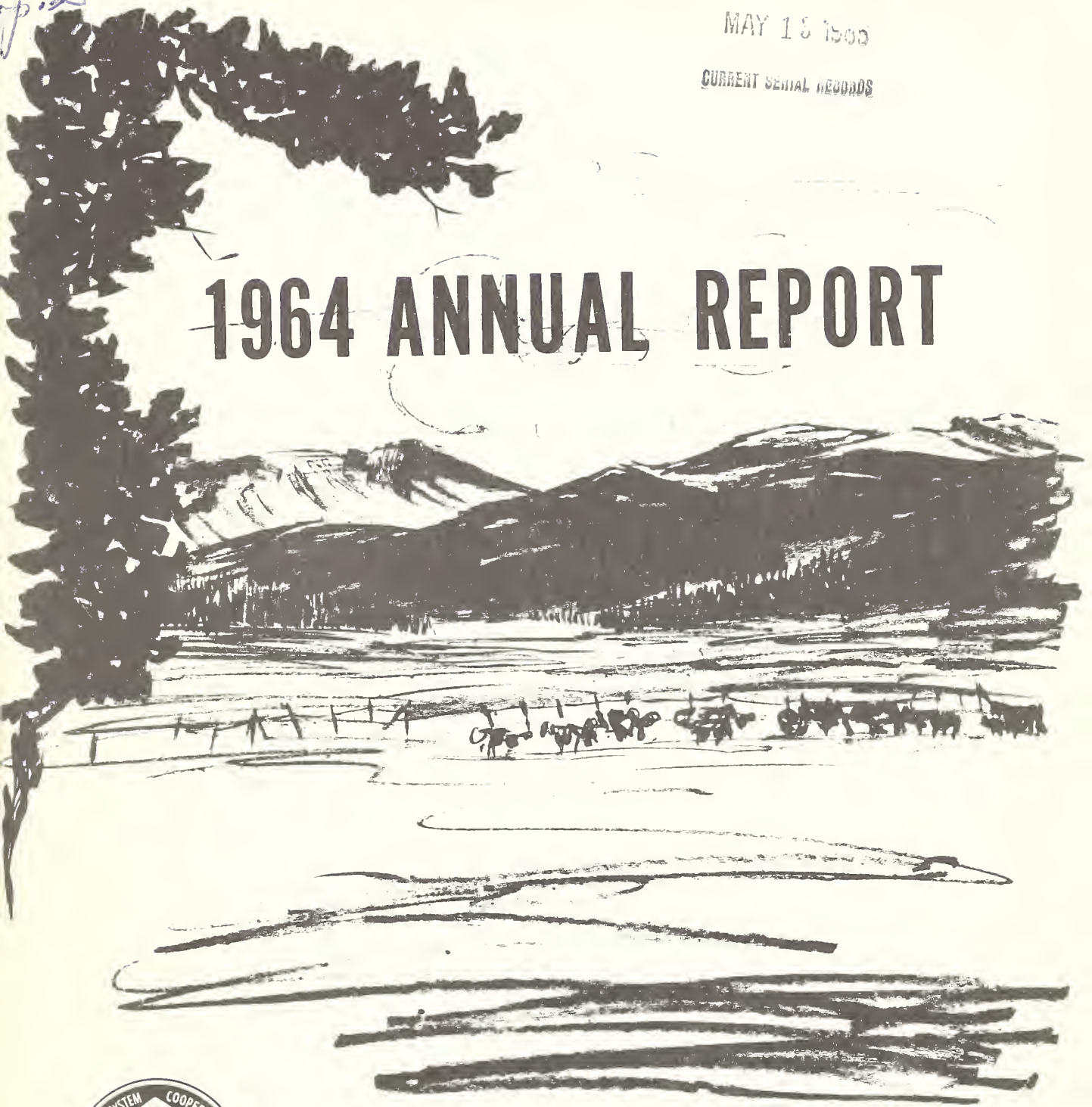
1964 ANNUAL REPORT



ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Forest Service U.S. Department of Agriculture

PROJECT LOCATIONS

Albuquerque, New Mexico
New Federal Building

Marron Hall
University of New Mexico

Flagstaff, Arizona
Forestry Sciences Laboratory
Arizona State College

Fort Collins, Colorado
Forestry Building
Colorado State University

Laramie, Wyoming
Forest Range and Watershed Laboratory
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
Forestry Sciences Laboratory
South Dakota School of Mines
and Technology

Tempe, Arizona
Forest Hydrology Laboratory
Arizona State University

Tucson, Arizona
Tumamoc Hill
University of Arizona

Station headquarters is at Fort Collins, Colorado,
in cooperation with Colorado State University

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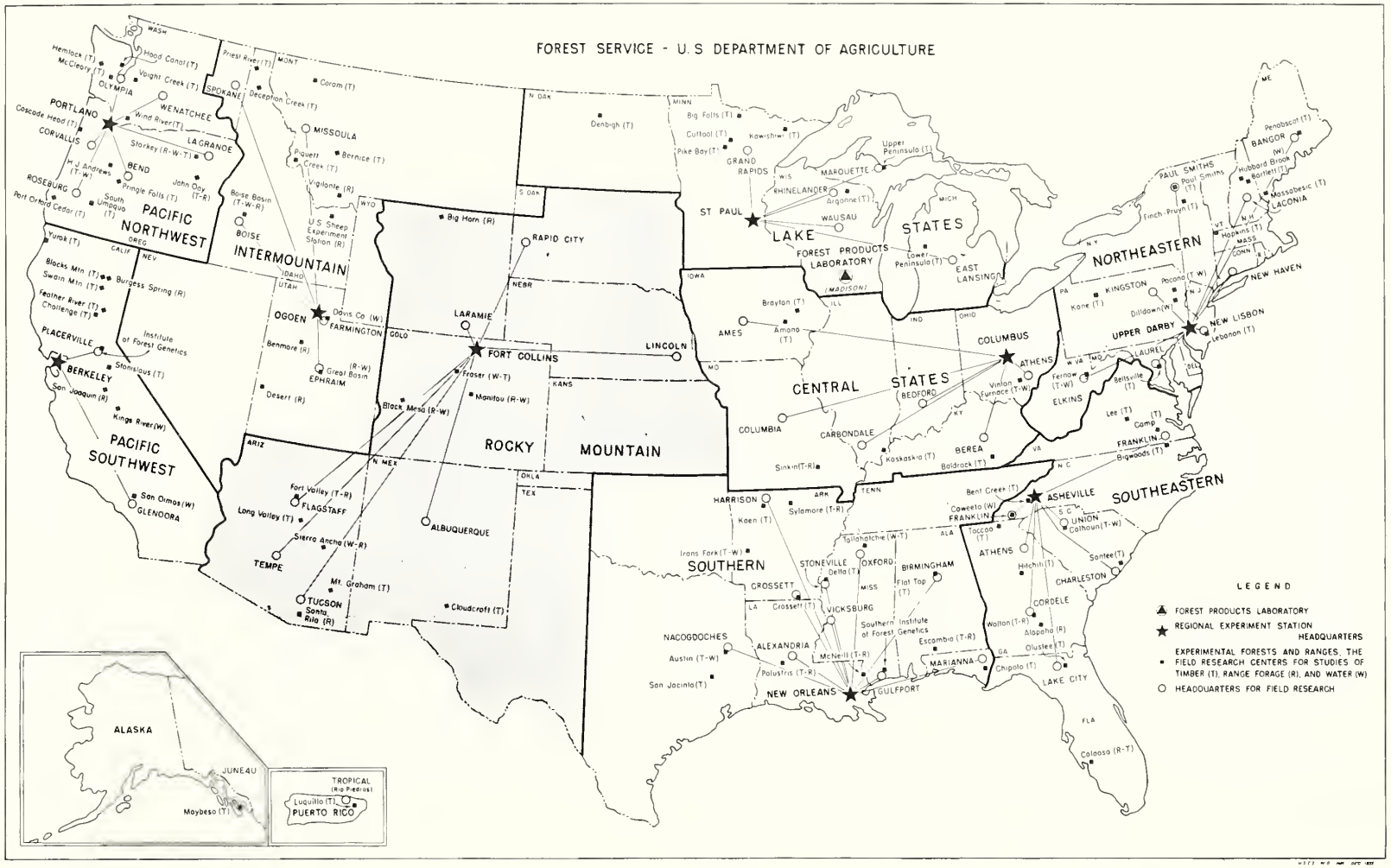


Location of the Forest and Range Experiment Stations and the Forest Products Laboratory

A brief summary

Timber Management Research continued to "tool up" for studies of growth and yield in several forest types. Site index curves for estimating relative productivity of environments were developed for ponderosa pine in the Southwest, for lodgepole pine throughout the West, for aspen in Colorado, and for Siberian elm in shelterbelts of the Central Great Plains. The lodgepole pine curves, prepared in cooperation with other western stations, include unique corrections for stand density. Volume tables and point-sampling factors were developed for lodgepole pine and for ponderosa pine in the Black Hills. A partly cut stand of aspen made remarkable 20-year growth in Arizona.

Needles of ponderosa pine seedlings exposed to drought can lose at least 0.3 of their moisture without injury. Uninjured needles will resaturate when removed from the tree and inserted in water. Drought injured needles will not resaturate completely.

Liquid urea applied as a top dressing was a more efficient source of nitrogen for lodgepole pine seedlings in a nursery than either urea formaldehyde or urea in granule form. Direct seeding of ponderosa pine and Mexican white pine holds promise in the mixed conifer zone of the Southwest, provided rodent control is effective.

Forest Fire Research used both the fundamental and applied approaches to study the use of fire. Flammability of living chaparral depends in part on moisture content and in part upon flammable, volatile constituents. Foliage moisture of chaparral species ranged between 63 and 92 percent during the year. Foliage of the same species lost from 0.4 to 0.6 of their ether extractives and about 1 percent of their heat value upon drying in the sun.

Prescribed burning of two plots in a pole-sized ponderosa pine stand consumed 0.4 of the litter layer (by weight), leaving only the decomposed layer.

Forest Products Utilization Research continued in the development of products and practices that will provide for more profitable and complete utilization of sawtimber and related residues. The area's first Engelmann spruce plywood plant is under construction, and an inventory system for evaluating the suitability of standing timber for a wide range of primary products has been developed. Efforts to better identify important defects in standing timber showed that, although degree of lean in ponderosa pine sawtimber is the most conspicuous indicator of compression wood, it does not always account for its presence.

Studies to establish basic factors influencing the weight-volume relationship of saw logs showed that moisture content of standing trees in the Black Hills area reached a maximum during winter. Cut logs stored outdoors for 100 days in the same general area during the summer and early fall averaged 5.3 percent weight loss. Storage conditions varying from dense shade to no shade appeared to alter the rate of loss very little, with approximately 50 percent of it occurring in the first 2 to 3 weeks.

Forest Insect Research emphasized (1) biological control of several species of tree-killing bark beetles and a tent caterpillar, (2) attraction of the Black Hills beetle, and (3) causes of sudden changes in infestation trends of spruce budworm outbreaks. More specifically, the application of two insect pathogens, a polyhedrosis virus and a bacterium, to an infestation of a tent caterpillar increased the incidence of the diseases to 81 percent of the colonies. Techniques for rearing nematode parasites of bark beetles on artificial media are being intensively studied. Several spruce budworm infestations are being analyzed to

identify the key natural control factors. Good progress is being made in learning how to rear the Black Hills beetle in large numbers for use in future studies of biological control, chemical control, sterilization, attraction, and dispersion. Field tests of attractants for the Black Hills beetle demonstrated possibilities for application in control of this bark beetle.

Forest Disease Research placed greatest emphasis on basic and applied studies of dwarfmistletoes. In a continuation of taxonomic research on the genus Arceuthobium, four dwarfmistletoes common to the Southwestern United States and a number of other valid species were collected in Mexico. Results of inoculations with lodgepole pine dwarfmistletoe indicate that shoots are formed 3 to 4 years after infection. This time interval is important in planning dwarfmistletoe control projects.

As a result of intensive etiological research, two species of Ceratocystis are prime suspects as the cause of aspen cankers in the Central Rocky Mountains. In other etiological studies, inoculations demonstrated the pathogenicity of Neopeckia coulteri, the recognized cause of brown felt blight of lodgepole pine. In the Southwest, continuing nematological research revealed that a root knot nematode belonging to the genus Meloidogyne parasitizes the roots and causes foliage discoloration in mature ponderosa pine. In the Central Great Plains area, it was found that Dothistroma needle blight of Austrian pine can be controlled with Bordeaux mixture.

Range Management and Wildlife Habitat Research delved more deeply into fundamentals of plant and animal ecology. Seedlings of Thurber fescue, a grass dominant on many mountain grasslands in the central Rockies but less abundant than in former years, were found to require more moisture for survival and full development than those of associated Idaho fescue. Abundance of true mountainmahogany, a valuable browse plant for big game and livestock, was found to be related to soil fertility.

Proper grazing intensity and deferment of use until the end of the growing season in alternate years resulted in a substantial increase in the grazing capacity of semidesert grassland ranges in Arizona. For those ranges, on which size of forage crop varies greatly from year to year, the amount of perennial grass produced for each inch of summer rainfall received has proved to be useful in determining whether condition of the range is improving.

A chemical desiccant, sprayed on the foliage of juniper several days before the trees were burned, greatly facilitated control of individual trees that had invaded grasslands in northern Arizona. Other chemicals, sprayed on newly established shrubs in the Black Hills of South Dakota, effectively prevented overbrowsing by deer during winter months.

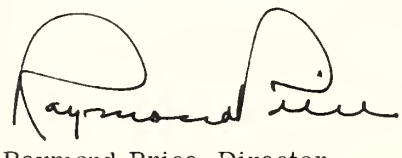
Watershed Management Research is stressing basic processes that operate in a watershed: how soils, plants, snow cover, topography, geologic formations, and climatic conditions affect watershed behavior and its functions. Special attention has been given to learning more about the important factors that comprise a watershed, and how these factors function in terms of water yield, soil stability, erosion, and vegetation cover.

Basic studies such as: (1) growth patterns in chaparral shrubs, (2) infiltration rates in chaparral soils, (3) vapor transfer in and from snowpack, (4) sap velocity, (5) hydrology of mountain bogs, and (6) soil moisture under sprayed and unsprayed sagebrush, are now underway.

Avalanche research is stressing the important field of hazard prediction. The accuracy of such predictions can be improved through a better understanding of the physical and mechanical properties of the snow and of mountain weather.

The first comprehensive test of the effectiveness of gully control structures is now complete through the installation phase.

Details of these and other findings are presented in the following pages. Complete accounts of our research are released through various publications. An annotated list of publications issued in 1964 is included in the bibliography at the end of this report.



Raymond Price, Director

Timber Management and Forest Fire Research

Site indexes developed
for four important tree species

Height-over-age curves were developed for rating the productivity of three important forest tree species and one important shelterbelt species. The site-index curves for ponderosa pine[1] in the Southwest, lodgepole pine Westwide, and aspen are the first ever prepared that will have general application to forest trees in the areas specified. The site indexes for Siberian elm are the third that have been prepared for Plains windbreak trees. All indexes were prepared from stem analyses.

The site indexes for ponderosa pine are applicable to even-aged stands in Arizona and New Mexico. The curves express heights of dominant trees at ages measured at breast height (fig. T-1).

The lodgepole pine site study was conducted in cooperation with the other western experiment stations. Because height growth of lodgepole pine is restricted when the trees are crowded, a unique adjustment for stand density was developed.

The aspen site indexes were developed from trees sampled in Colorado, New Mexico, and Arizona. There were no significant differences between the States, so the indexes should be usable in the three States.

[1]*Common and botanical names of the plants mentioned are listed inside the back cover.*

The indexes for Siberian elm illustrate both one of the dangers and a special use of height-over-age curves. Since the forms of the curves differed by soil types, it was necessary to prepare separate sets for each major soil type studied (fig. T-2). This points up a danger in using one set of site-index curves on a variety of habitat conditions. On the other hand, the differences in height-over-age relations can be used to indicate different soils. Short-term deviations from established height-growth patterns can be used to gage impact of climatic fluctuations, insect attacks, diseases, and so forth.

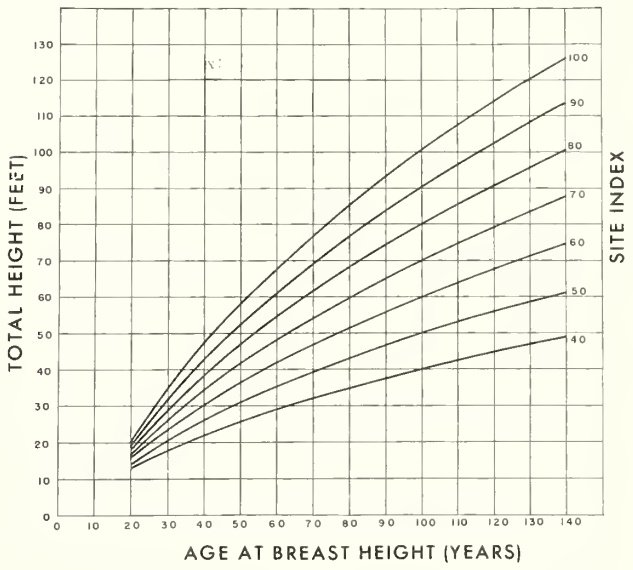


Figure T-1.--Site index curves for even-aged ponderosa pine in the Southwest.

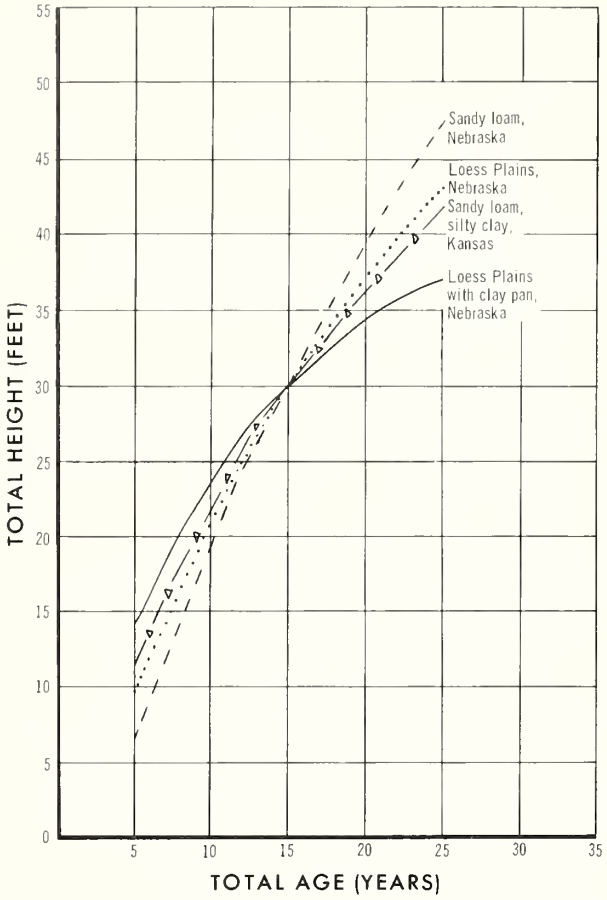


Figure T-2.--Contrasting shapes of height-over-age curves for Siberian elm growing on 4 different soils in Nebraska and Kansas. All are site index 30 at base age 15 years.

Sample size influences reliability of site-index determinations

Reliability of site-index determinations in an even-aged stand depends on the number of trees measured to obtain average height and age, and on the suitability of these trees. It is usual procedure to exclude unsuitable trees from the sample--those that have been suppressed, are diseased, have lost the upper part of the bole, or are not in the crown classes sampled to construct the site-index curves. Less attention is sometimes given to the number of trees measured.

Data from uniform 1/5-acre plots in ponderosa pine stands of the Black Hills indicate the variation to be expected on small areas, and the effect of sample size on sampling errors in site-index determinations. The standard deviation of site index within plots was 3.66 feet. Sampling errors were as follows:

Number of trees measured per plot:	Standard error (feet)	Sampling error at 95 percent level of probability (feet)
3	± 2.12	± 9.1
4	1.83	5.8
5	1.64	4.5
6	1.50	3.8
7	1.38	3.4
8	1.30	3.1
9	1.22	2.8

Under rather ideal conditions of limited areas carefully selected to contain at least six trees suitable for measurement, a sample of three resulted in a sampling error of 9 feet. Increasing the number of trees measured on a plot materially reduced sampling error until about six trees were measured. Each tree measured after the sixth gave little added improvement in sampling error for the increased work involved.

Good growth produced by aspens in Arizona

The residual trees in a 50-year-old aspen stand on the San Francisco Peaks of northern Arizona increased 95.8 cubic feet per acre annually during the first 20 years after release by commercial cutting (fig. T-3). This was an average increase of 1.3 cords per acre per year.

Rodents damage direct seedings in mixed conifer zone of Southwest

Mexican white pine and ponderosa pine were spot-seeded at 9,300 feet elevation on the Apache National Forest in October 1962. All vegetation was removed mechanically before seeding on half the plots, while the cover of bunchgrass and forbs was left on the others. The seeds were sown in small prepared spots,

Figure T-3.--Uncut aspen on the west slope of San Francisco, Peaks, Arizona.

three seeds in each spot. Half the spots of each species were screened to exclude rodents; deer, elk, and cattle were fenced out of all plots.

After two growing seasons, stocking averaged 31 percent in the screened spots, only 8 percent in the unscreened. Stocking was about the same for both species and both methods of site preparation.

Rodents burrowed under most of the screens, so that protection was only partially effective. Postgermination protection against rodents was as important as pregermination protection.

Frost heaving caused more than three times as much mortality of ponderosa pine as of Mexican white pine, which suggests that Mexican white pine may be better suited to situations in the mixed conifer zone with a special frost-heaving hazard.

Heat injury was a problem only among Mexican white pine seedlings that germinated in the spring; none was found after the summer rains began.

Determining water balance of ponderosa pine needles

Ponderosa pine needles tightly wrapped in thin plastic food wrap were brought to the laboratory for water-balance studies. It was found that needles so treated could be stored at room temperature for up to 18 hours without significant loss of green weight or capacity to resaturate.

Water balance was determined by weighing the needles, then allowing them to saturate for 24 hours in a small amount of water in a test tube. The needles absorbed water rapidly for the first 8 hours, and continued to take up very small amounts for 24 hours.

Needles subjected to severe drought may not fully recover their former turgidity after the drought is broken. Freshly cut needle fascicles were saturated and subjected to simulated drought conditions by drying until various water saturation deficits (WSD) up to 42.2 percent were reached. The needles were then resaturated and reweighed. Differences in water content between first and second saturations (water resaturation deficit, WRD) became progressively larger as the WSD increased. The needles also lost dry weight during the simulated drought, which increased the apparent WRD about 3 percent at WSD of 38 to 42 percent. (fig. T-4).

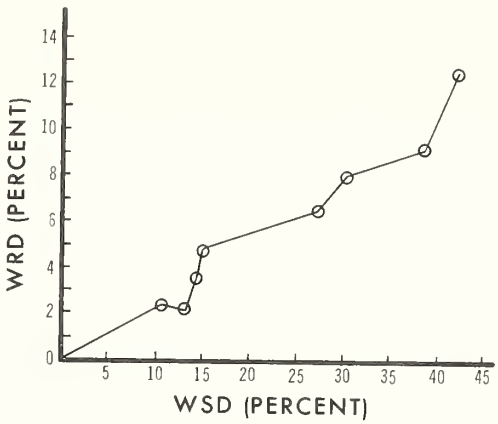


Figure T-4.--Influence of simulated drought, expressed as water saturation deficit (WSD) on capacity of ponderosa pine needles to resaturate, expressed as water resaturation deficit (WRD). Each point represents five needle fascicles.

Liquid urea topdressing is efficient source of nitrogen in a forest nursery

Lodgepole pine seedlings in seedbeds at Bessey Nursery, Nebraska, responded more to nitrogen added as a liquid topdressing than as dry granules mixed with the soil. Soil in the seedbeds was low in total nitrogen (0.040 percent) and high in phosphorus (60 to 70 p.p.m.) and potassium (200 to 300 p.p.m.). Nitrogen applications were as follows:

Nitrogen source	Pounds applied per acre
Urea formaldehyde granules	80, 160, 240, 320, 400, 480, 560, 640
Urea granules	80, 160, 240
Liquid urea topdressing	100

Granular sources were rototilled into the soil before seeding. There was little response to added nitrogen during the first growing season. Urea topdressing was applied during the second growing season in two equal treatments of 50 pounds of nitrogen per acre.

At the end of the second growing season, urea formaldehyde had increased seedling dry weight only for applications greater than 320 pounds of nitrogen per acre. Needle length increased with applications greater than 160 pounds per acre. Urea granules had no measurable effect on seedling growth at the rates of application tested. Urea topdressing, applied during the second growing season, produced the largest and heaviest seedlings--16 percent taller than the tallest obtained with other treatments. At least 400 pounds of nitrogen from urea formaldehyde were required to produce seedlings having stem calipers, needle lengths, or top-root ratios equal to seedlings obtained from 100 pounds of nitrogen from liquid urea topdressing. This was probably due to leaching losses from the granules during the first year.

Liquid urea was six times more efficient as a source of nitrogen than the best urea formaldehyde treatment. Seedlings treated with liquid urea topdressing recovered 37 percent of the applied nitrogen, compared with 6 percent recovery from the 560-pound application of urea formaldehyde. Greatest recovery from urea granules was 0.7 percent from 240 pounds of nitrogen per acre.

Top-root ratios and other indicators of seedling quality were not adversely affected by the nitrogen treatments.

A West-wide CCF equation developed for lodgepole pine

Crown competition factor (CCF), a measure of stand density developed by the Central States Forest Experiment Station, was adopted as a basis for adjusting site indexes of lodgepole pine for stand density.

Personnel of the Rocky Mountain, Intermountain, and Pacific Northwest Forest and Range Experiment Stations measured the diameters at breast height and crown widths (CW) of 775 open-grown trees to establish a regression equation expressing CW in terms of diameter.

Separate equations were first developed for each region. The correlation coefficient of each equation was highly significant. Although the intercept value of the Intermountain equation was significantly lower than that of the other two, the regression coefficients did not differ significantly, and the regression lines were virtually parallel. Since the actual differences were so small, the data from the three sources were combined into the following equation based on the combined data:

$$CW = 3.27 + 1.423D,\ r = .9411,\ S_{\bar{y}} = \pm 2.60 \text{ feet}$$

The regression line computed from that equation is the best average measure of the relation of CW to diameter for the three areas.

The CCF equation which follows was then computed from the combined data.

$$CCF = \frac{1}{A}\left[(0.0192 \sum N) + (0.0168 \sum DN) + (0.0036 \sum D^2 N)\right]$$

Where CCF = Crown Competition Factor
A = Area in acres
N = Number of trees in each d.b.h. class
D = Individual d.b.h. or d.b.h. class

Prescribed burns attain objectives in ponderosa pine

Two homogeneous half-acre plots in a stand of large poles were burned during the following conditions:

Air temperature	79°-83°F.
Fuel temperature	74°-80°F.
Upper litter moisture	6.6 percent
Lower litter moisture	21.6 percent
Wind velocity in the flame zone	2-6 m.p.h.
Wind velocity in the open	5-11 m.p.h.

The objective was to develop a uniformly hot ground fire and measure its effects. The desired intensity was achieved (fig. T-5). Fire consumed 74 percent of the litter by volume or 79 percent by weight--all except the decomposed layer. This appears to be near optimal reduction for watershed management objectives.

Fuel characteristics differ between two chaparral shrubs

Two of the most common Arizona chaparral species, shrub live oak and pointleaf manzanita, differ importantly in some fuel characteristics. Manzanita foliage retained more moisture than shrub live oak foliage in the dormant season, but fluctuated more and became drier at times during the growing season:

	Moisture changes	
	Winter	Summer
	(Percent)	
Shrub live oak:		
High	80	85
Low	70	77
Pointleaf manzanita:		
High	92	93
Low	84	63

Chemical and energy relationships of oak and manzanita were determined in two conditions--fresh samples and samples collected after brush was severed and left in the field until leaves had dried. Pointleaf manzanita foliage contained more ether-extractable constituents (oils, waxes, and so forth), and had a substantially greater heat of combustion than shrub live oak:

	Extracts (Percent of ovendry residues)	Heat of combustion (B.t.u. per pound)
Shrub live oak:		
Fresh	6.2	8,200
Severed	2.6	8,100
Pointleaf manzanita:		
Fresh	14.3	9,100
Severed	8.5	9,000

Each species lost 40 to 60 percent of its ether-soluble constituents and 1.1 to 1.2 percent of its heat value upon air drying.

Figure T-5.--This hot ground fire reduced forest litter by 75 to 80 percent.

These fundamental differences in species, and changes that accompany drying, have not yet been interpreted in terms of fire behavior.

Lodgepole pine reproduction influenced by seedbed condition and amount of slash

The establishment of natural reproduction in nine seedbed-slash density categories, created by logging and slash disposal, was studied on one small clearcut area on the Medicine Bow National Forest, Wyoming, from 1959 through 1963. As all parts of the study area were within 3 chains of an uncut timber seed source, seed for restocking came from both slash and standing trees.

Numbers of new seedlings after 5 years differed with both seedbed condition and slash density. Seedlings were most numerous on disturbed mineral soil seedbeds, and least on burned. On the unburned seedbeds, seedlings were most numerous where slash was absent or light, less numerous where slash was medium or heavy. The generally coarse residual slash on the burned areas had no apparent influence on reproduction (fig. T-6).

Stocking after 5 years was high on disturbed mineral soil seedbeds, acceptable on burned seedbeds, and too low on undisturbed seedbeds. Because of uniform distribution of seedlings, however, burned areas had the best stocking with fewest excess seedlings. All burned seedbeds, regardless of slash density, had more milacres stocked with one and two seedlings, or one to five seedlings, than any other treatments (fig. T-7). Few milacres had more than five seedlings. Although total stocking was higher on disturbed mineral soil, from 40 to 60 percent of all milacres had six or more seedlings.

It should be remembered that fire destroys seed in slash. Seed for restocking the burned areas in this study undoubtedly came from the nearby standing trees.

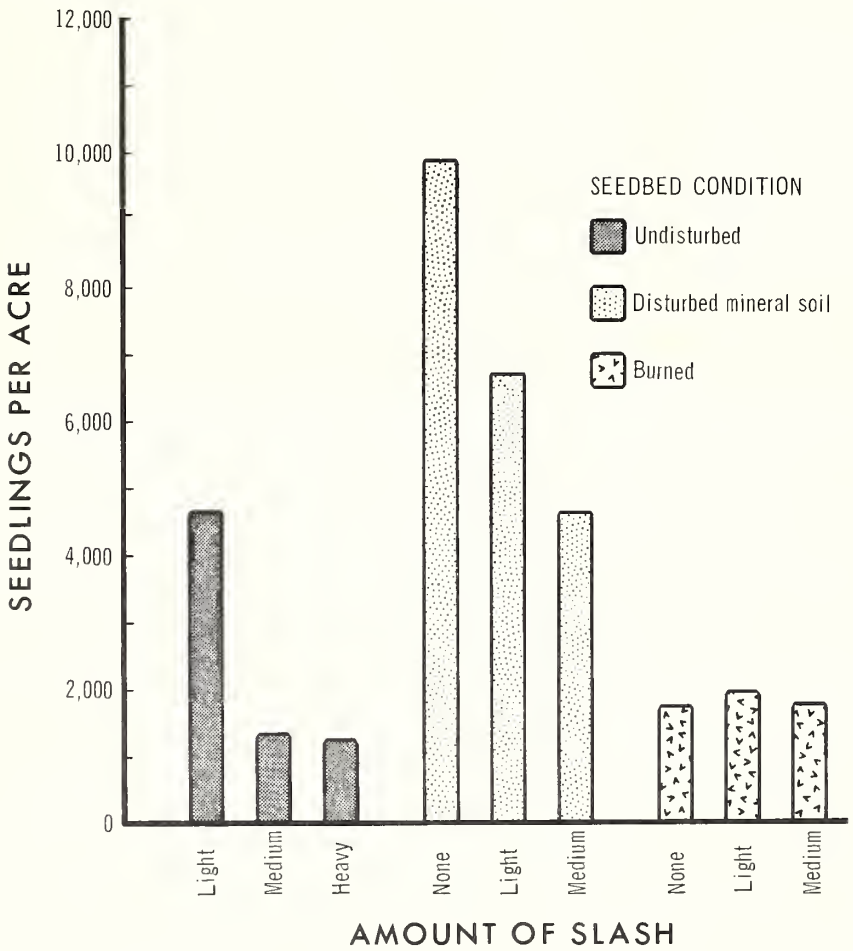


Figure T-6.--Number of seedlings in 1963 for each seedbed-slash density category. All data on a per acre basis.

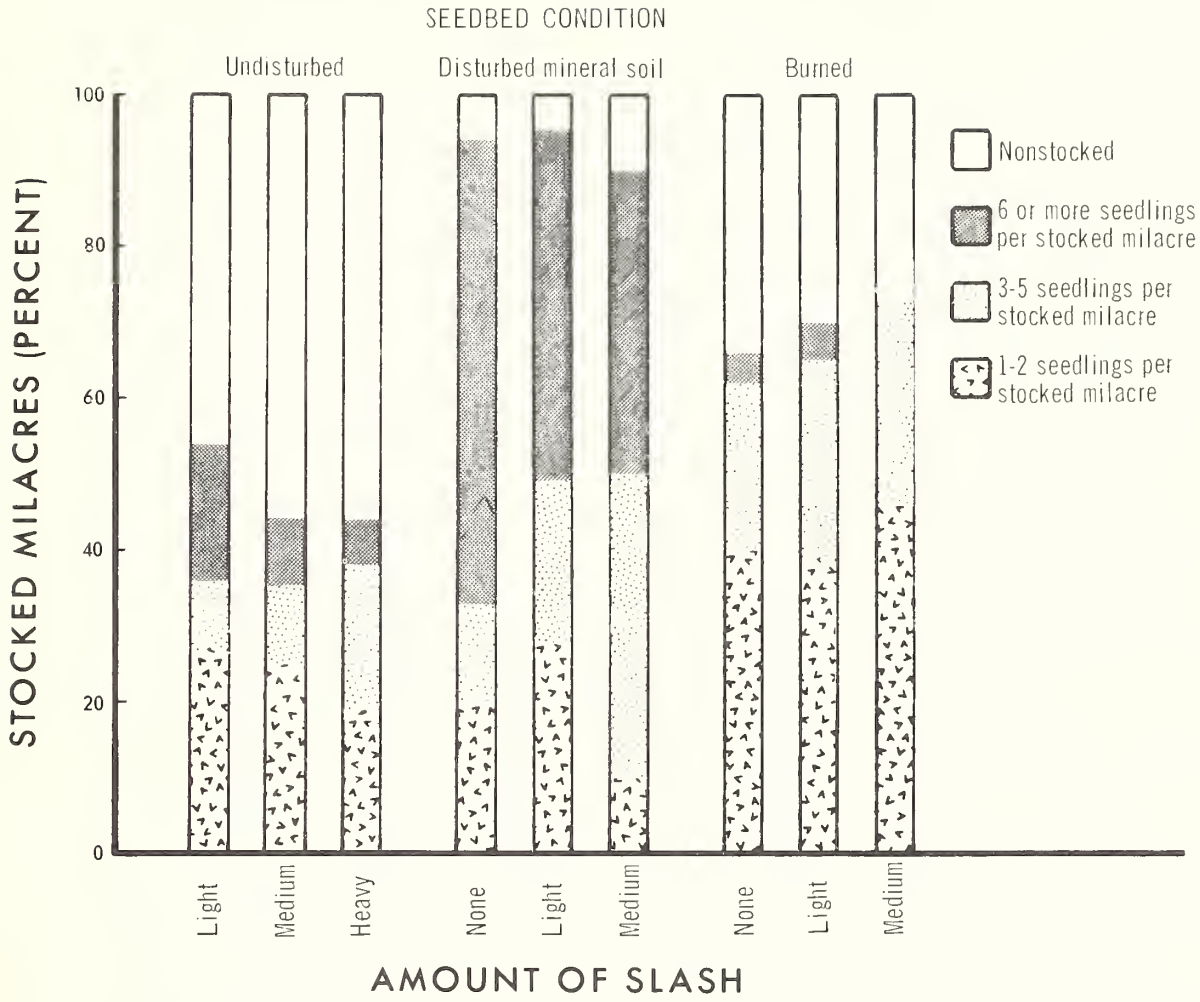


Figure T-7.--Stocking of seedlings and percentage of milacres stocked with different numbers of seedlings in 1963 for each seedbed-slash density category.

Forest Utilization Research

Areo's first plywood plant
to use Engelmonn spruce

Ground was broken this year for the first plywood plant in the Central Rockies. The new plant, located in southwestern Colorado, will draw on one of the largest available stands of Engelmann spruce for raw material. Sheathing-grade plywood will be the major product. Tests have shown that Engelmann spruce in the area lends itself readily to plywood production, and yields suitable volume of veneers in the grades required for sheathing-type plywood. The new plant will have an annual production of approximately 70 million sq. ft., 3/8-inch basis, which will require about 30 million bd. ft. of veneer logs. The new venture will provide employment for about 175 people, and constitute an important stride in overcoming some of the problems created by the continued decline in the lumber market.

Method developed for multi-
product timber inventory

Increased emphasis upon new products and conversion practices, and broader product diversification, has focused attention on problems of estimating the product potential of standing timber. Specific grading systems are inadequate for multiproduct appraisal--evaluating the suitability of standing timber for a wide range of products. A method has therefore been developed that incorporates fundamental stem and stand quality measurements necessary to predict yield and quality for diverse products.

The inventory system provides a means for estimating volume and quality of material for any one of a number of primary products. The effects of observed stem features upon usable volume and quality for a particular product can be calculated and applied to gross stand data to estimate net volume and material quality.

The inventory system was developed in cutover ponderosa pine stands, and has been used to inventory over 2,000 acres of such timber (fig. U-1). To provide a broad base for evaluation and revision, it has been used under a wide range of timber type and site conditions, including ponderosa pine--mixed-conifer stands, and high-quality old-growth ponderosa pine. Although still in the developmental stage, the system appears to offer a high degree of flexibility and versatility in evaluating timber quality for a wide array of products.

Occurrence of compression
wood studied in southwestern
ponderoso pine

Compression wood and its attendant wood quality implications are important factors to consider in appraising ponderosa pine timber quality. Previous research has indicated that lean, characteristic of southwestern ponderosa pine, may be one of the more important variables related to occurrence and severity of compression wood. Its occurrence is somewhat erratic, however, and better definition of

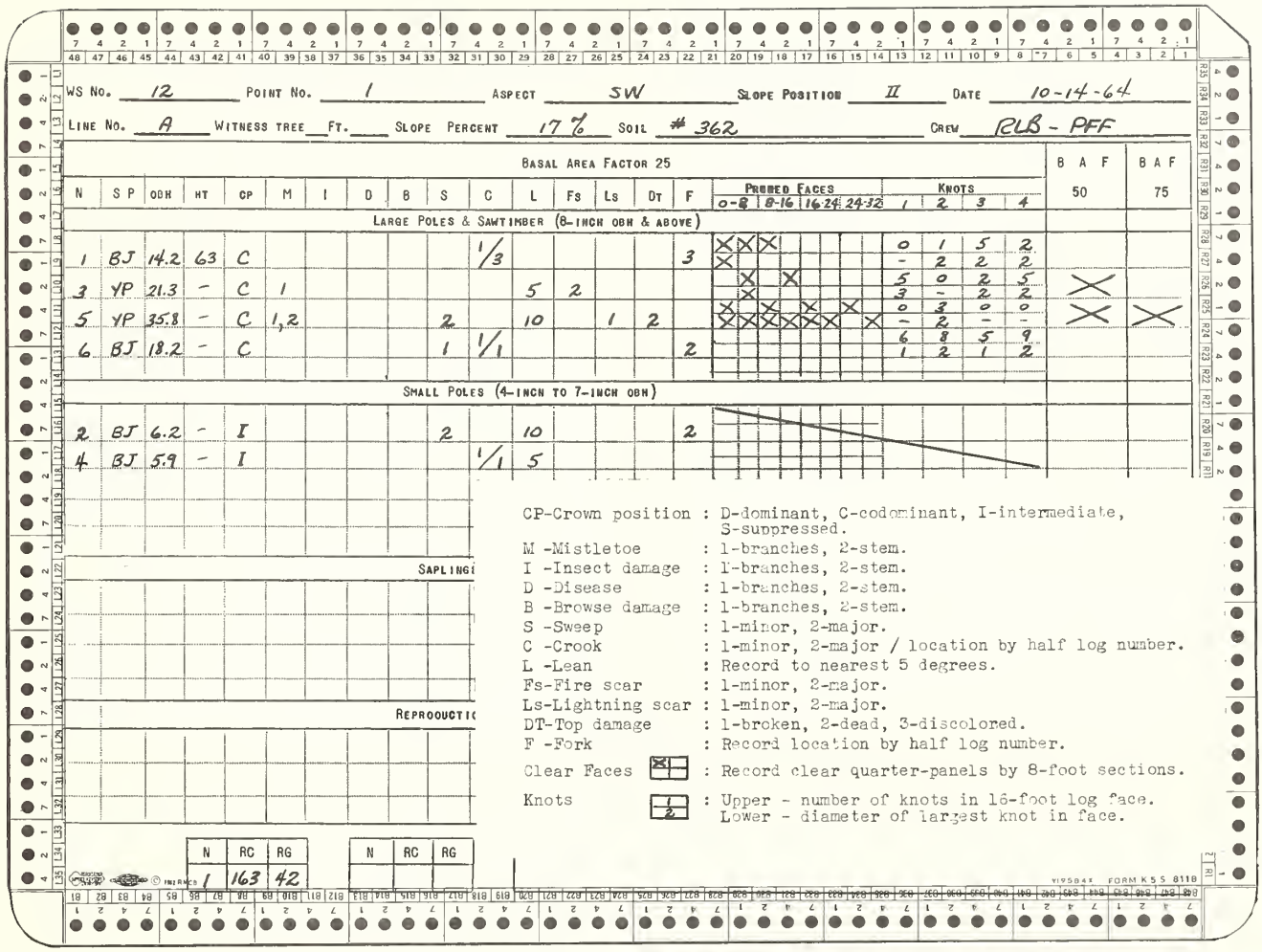


Figure U-1.--A field data card for recording sample tree size and quality information for an inventory sampling point. Information from field data cards is aggregated to develop stand and stocking information, and stem quality information, for the stand as a whole.

the relation between observable stem and stand characteristics and the formation of compression wood is needed. Thus the effect of selected tree stem and growth characteristics upon the occurrence and severity of compression wood is being evaluated in ponderosa pine sawtimber.

Sample trees, 125 "leaners" without additional abnormalities, were selected on an active sale area to provide a wide representation of tree size and degree of lean (fig. U-2). Field measurements included tree diameter, height, degree of lean, and stand competition expressed in terms of point-sample basal area. Full cross sections and increment core pairs were taken when the area was logged.

Because compression wood can be most accurately identified and classified by placing thin cross sections over a light source--compression wood appears opaque compared to normal wood--cross sections 3/16 inch thick were cut from the field samples for analysis (fig. U-3).

Three compression wood severity classes--"normal" wood, "intermediate" compression wood, and "severe" compression wood--based on relative opacity, were set up. Microanalysis of samples generally supported this transmitted-light classification. Typical characteristics of compression wood, including circular cell cross-sectional shape, large associated intercellular spaces, larger fibril angles, and shorter fiber lengths, were most

Figure U-2.--Leaning sawtimber trees were selected to provide a wide representation of tree size and degree of lean. Sample trees (banded) were restricted to "straight" leaners, without other stem defects such as sweep or crook.

Figure U-3.--Extent and severity of compression wood can be most accurately determined by observing the transmitted light pattern through a thin cross section. Opaque areas in the cross section are compression wood.

pronounced in samples classified severe, and became progressively less pronounced in intermediate and normal samples (fig. U-4).

The occurrence and severity of compression wood in the sample trees will be quantitatively described, and checked against recorded stem and stand characteristics to determine which, if any, can be used to predict compression wood in standing timber. Early findings indicate lean in itself does not always account for the presence or extent of compression wood.

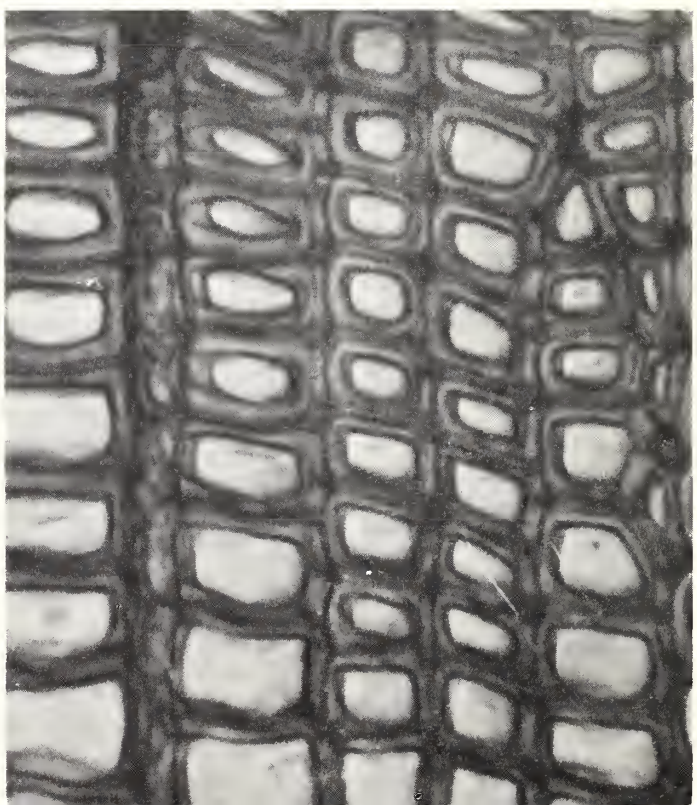


Figure U-4.--In cross section, the cells of normal wood (left) are rectangular with few intercellular spaces. Compression wood cells (center) are comparatively oval or rounded, with numerous large intercellular spaces. The cells of compression wood characteristically exhibit larger fibril angles than are common in normal wood (right). The spiral alignment of cell wall components contributes to the low strength and high longitudinal shrinkage common in lumber containing compression wood.

Tree moisture content in Block Hills is maximum during winter

Continuing studies to determine the feasibility of weight scaling Black Hills ponderosa pine included the determination of the effect of season and site on tree moisture content, and the weight loss of logs held in woods storage.

To determine tree moisture content trends by season, 50 trees--10 on each of 5 sites--were bored at breast height during each of 5 physiological periods. Increment cores one-half inch in diameter were taken, and separated into heartwood and sapwood segments.

Ponderosa pine sapwood moisture content varied from a late growing season low of about 125 percent, ovendry basis, to a winter dormancy high of about 147 percent. Heartwood, however, maintained a constant moisture content of about 30 percent, ovendry basis.

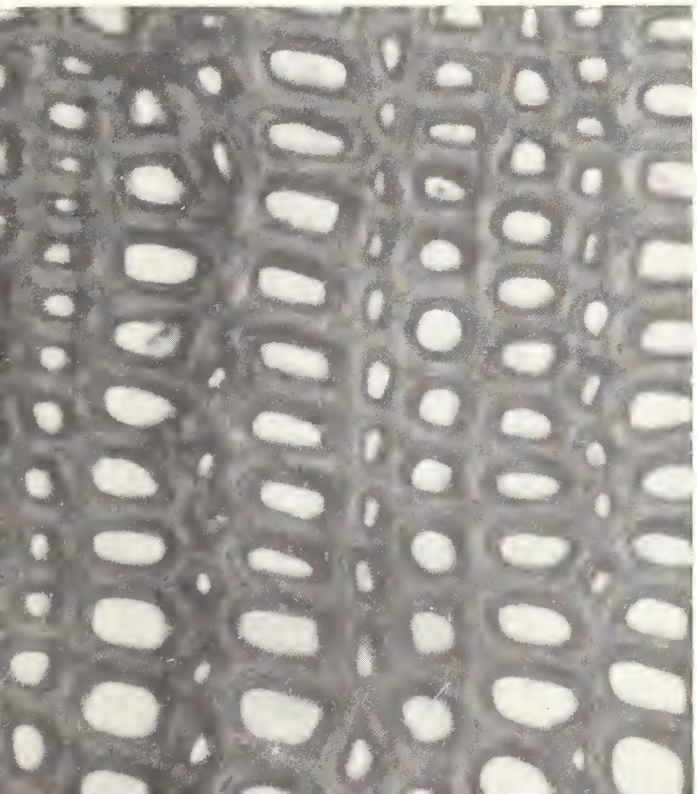
The study to determine weight loss of logs held in woods storage during the dry season was completed on 50 logs placed under 5 differing overstory conditions ranging from an open pasture to dense reproduction.

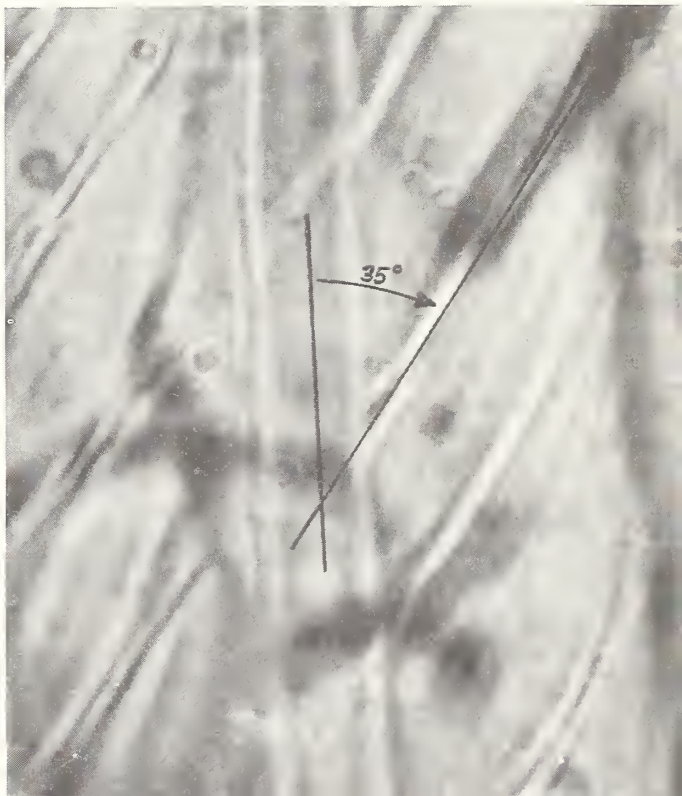
Weight loss differed only slightly among the 5 storage conditions during 110 days of summer and early fall storage. Total weight loss was 5.34 percent of the initial log weight of 42,045 pounds. About 44 percent of the total weight loss occurred during the first 16 to 20 days of storage. Some time between the 20th and 40th days of storage, ips beetles attacked the logs and blue stain began to appear. Bark began to loosen from the logs between the 40th and 60th day of storage. Lower temperatures, occasional showers, and snows minimized drying during the last 21 days of storage.

All logs from the same tree tended to lose nearly the same total weight, regardless of beginning weight or size. As a result, small logs from some trees had greater total weight loss than did much larger logs from other trees. For all trees, upper logs lost a greater percent of their initial weight than did butt logs.

Aerotion, nitrogen occelerote composting of ponderoso pine bork

A study of ponderosa pine bark composting was begun at Rapid City to develop a product





outlet for bark residue available in the area. To determine the amount of nitrogen and aeration required for successful composting in the South Dakota area, bark was first ground in a farm-type hammermill with a 3/4-inch-mesh screen. Nitrogen in the form of liquid urea, containing 33 percent available N, was added to the designated lots in the amount of 2.25 percent of the dry weight of the bark, and mixed in a commercial feed mixer. The treated bark samples and untreated controls were then composted in polyethelene-lined wooden bins. Bark from selected bins was aerated by weekly removal and replacement (fig. U-5).

Before the samples were composted, values for selected variables were determined, with some indicating considerable difference between nitrogenated and nonnitrogenated bark:

	Nitrogen	
	Added	Not added
Percent nitrogen (ovendry basis)	1.90	0.24
Percent carbon (ovendry basis)	46.62	48.99
Carbon-nitrogen ratio	24.5:1	204.1:1
Percent ash (ovendry basis)	8.38	5.44
pH	4.5	6.6

Differences in these variables before and after composting will be used to indicate the extent of composting over a given period of time. Also, a sieve analysis will be used to determine the extent of particle breakdown.

Temperatures of the composting bark gave an indication of early composting activity inside the bins. Remote-reading thermometer elements at the center of the bins indicated earliest and most active composting in nitrogenated and aerated bark. Nonaerated nitrogenated bark was next in apparent activity. Aeration of nonnitrogenated bark kept bin temperatures for this treatment below those of nonaerated controls.

Figure U-5.--Aerating bark during composting study at Rapid City, South Dakota.

Specific grovity of two woodlond species determined

Past utilization of Gambel oak and alligator juniper has been limited largely for fenceposts and fuelwood. There is continued interest, however, in further utilization of these species. Appraising suitability for possible new uses requires some knowledge of the physical characteristics of the woods. Specific gravity provides the best single index to such properties as wood strength, stiffness, shock resistance, hardness or wear resistance, and charcoal or fiber recovery.

Average specific gravity at breast height and variation in the specific gravity, based on ovendry weight and green volume and obtained from increment cores, for the two species are as follows:

	Gambel oak	Alligator juniper
Number of trees sampled	48	46
Specific gravity:		
Maximum	0.706	0.533
Minimum	.569	.372
Mean	.634	.453
95 percent confidence interval	± .010	± .010
Density (Lbs./cu.ft.):		
Mean	39.6	28.3
95 percent confidence interval	± .62	± .61

These data show specific gravities for both species below values reported earlier.[2] In view of the stronger bases, however, 48 trees compared to 3 of the Gambel oak and 46 to 1 for the alligator juniper, the current values are more representative.

[2]*Markwardt, L. J., and Wilson, T. R. C. The strength and related properties of woods grown in the United States. U. S. Dept. Agr. Tech. Bul. 479, 99 pp. 1935.*

Forest Insect Research

Virus, bacterium tested to control a tent caterpillar

A pilot test on approximately 50 acres of cottonwood and willow near Tucson, Arizona, to control an infestation of a tent caterpillar (Malacosoma sp.) with two insect pathogens shows promising results. A water suspension containing a nuclear polyhedrosis virus and the bacterium Bacillus thuringiensis (Berliner) was applied by helicopter against third-instar larvae (fig. I-1). Each acre was treated with 2 gallons of spray containing 50 billion polyhedra and approximately 1 fluid ounce of a commercial Bacillus thuringiensis preparation.

Percent of tent caterpillar colonies containing disease-killed larvae after 9, 15, and 24 days was as follows:

Host	Days after treatment		
	9	15	24
		Percent	
Cottonwood	27	62	81
Willow	47	44	66
Control (both hosts)	0	0	7

The incidence of infected colonies in the untreated area was negligible; incidence of infected larval colonies increased with length of time after treatment. A slightly greater percentage of the colonies on the cottonwood trees contained infected larvae than on the willow trees, probably due to the greater surface area for spray deposit on the more advanced foliage growth at the time of the treatment.

Figure I-1.--Suspensions of a nuclear polyhedrosis virus and the bacterium Bacillus thuringiensis (Berliner) are added to water in the helicopter tanks for spraying on a tent caterpillar infestation.

Final success of the application will depend upon the virus carrying through to the 1965 generation of caterpillars and causing more complete mortality.

Nematode porosites of bork beetles reored ortificiolly

Six species of external nematode parasites of the roundheaded pine beetle, Dendroctonus adjunctus, and the Engelmann spruce beetle Dendroctonus obesus, were successfully reared on culture media composed of freeze-dried phloem of ponderosa pine or Engelmann spruce, and agar and distilled water. Unfortunately, these external nematode parasites probably have little importance as biological control agents. Only the internal parasitic species are known to be important. Attempts to rear the internal species on various culture media have failed. Certain stages in the life cycle of the internal species studied to date require the living bark beetles in which to develop.

Figure I-2.--Spruce budworm injury is especially severe in some areas on the understory trees.

The internal nematode, Contortylenchus elongatus, has been successfully reared under laboratory conditions in the California five-spined ips, Ips confusus (Lec.), infesting pinyon pine bolts; and Parasitylenchus elongatus in the fir engraver, Scolytus ventralis Lec., infesting white fir bolts. Better biological controls for tree-killing bark beetles could result when research is successful in finding ways to rear internal nematodes on artificial media.

Spruce budworm infestotions being onolyzed

The outbreak behavior of the spruce budworm, Choristoneura fumiferana (Clem.), in the central and southern Rocky Mountains is different from its behavior in other parts of its range in North America. In small, localized outbreaks, large populations develop rapidly and cause severe defoliation of current growth for only 1 or 2 years. Occasionally, outbreaks may involve thousands of acres with high populations persisting for several years. Repeated defoliation of current growth results in top-killing, increment losses, and mortality of understory reproduction (fig. I-2). Most outbreaks are terminated by unknown or unrecognized influences.

Several infestations are being analyzed to identify the most important causes of natural population declines. Specifically, the numerous insect parasites of the budworm are being inventoried to evaluate their relative effectiveness as control agents. Also, methods of detecting changes in the egg-laying capacities of the female moths are being tested. Such research should uncover the key natural-control factors, and lead to more precise methods of predicting infestation trends needed to plan control.

Techniques for rearing Block Hills beetle being developed

Studies were continued to determine optimum conditions for rearing the Black Hills beetle (Dendroctonus ponderosae Hopk.) in

freshly cut bolts from ponderosa pine. Large numbers of the beetle are needed for evaluating natural-control agents. At the optimum temperature of 70°F. determined previously, varying humidity in rearing cabinets from 40 to 80 percent had no influence on rate of brood development or number of progeny. Changes in atmospheric pressure also had no apparent influence on beetle emergence. Emergence started 10 weeks after egg laying started.

Alternating periods of low temperature did not influence total emergence period, but did cause day-to-day changes, the magnitude of which requires further testing. The reared beetles were as large as their parents, and early-emerging progeny were no larger than late-emerging ones.

Bolts from some trees produced more beetles and at a higher rate than other trees.

Figure I-3.--Cage attractant. Beetles placed in the cage before natural emergence attack the tree and set up attraction for other beetles.

Block Hills beetle attractant promising as control tool

Active female Black Hills beetles (Dendroctonus ponderosae Hopk.) in bolts and cages (figs. I-3; I-4) attracted other beetles from unknown distances into specific groups of ponderosa pines, thereby demonstrating their possible application as a control tool. Their use may have the greatest application in treating light infestations in which infested trees are scattered over a wide area. Such infestations are costly to treat because of the large amount of time required to locate and treat the infested trees before the beetles fly. If these emerging beetles can be drawn into trees in accessible areas, spotting costs would be eliminated and beetle control practical. Additional field tests are planned to determine the spacing of attractants required to draw all beetles from the infested area.

Figure I-4.--Bolt attractant. Beetles are forced to emerge and infest the bolt in the laboratory. The infested bolt is attached to a green tree to attract normal emerging beetles.

Forest Disease Research

Taxonomic study of dwarfmistletoes extended to Mexico

In a continuation of field and herbarium studies aimed toward a taxonomic revision of the genus Arceuthobium, four dwarfmistletoes common to the Southwestern United States have been collected in Mexico: A. douglasii, A. campylopodum f. blumeri, A. vaginatum f. cryptopodum, and the newly described A. gillii. Studies of these and a number of other valid species, some previously undescribed, suggest that the point of origin of dwarfmistletoes in this hemisphere may lie "south of the border."

Lodgepole pine dworfmistletoe shoots formed 3 to 4 yeors ofter infection

Results from a series of seed inoculations made over several years with lodgepole pine dwarfmistletoe (Arceuthobium americanum) indicate that it takes from 2 to 5 years for this parasite to produce shoots. About 90 percent of the plants first produced aerial shoots 3 or 4 years after inoculation. Knowledge of the interval between natural seed discharge and shoot appearance is important in timing followup operations in dwarfmistletoe control projects.

Cerotocystis prime suspect os couse of aspen conkers

The Nectria-like canker of unknown cause in Colorado appears similar to the recently described canker of quaking aspen in Minnesota caused by Ceratocystis fimbriata (Ell. and Halst.). This fungus has been consistently isolated from wood and bark tissue along the margins of Colorado aspen cankers. Perithecia of the fungus have been found on the cankers during moist periods.

Because C. fimbriata causes cankers on other hardwood trees as well as a soft rot of sweet potato, inoculation tests to prove pathogenicity were started with isolates from aspen in Colorado and Minnesota, sycamore in Mississippi, and sweetpotato. Small cankers were evident 3 months after inoculation with all four isolates, but observations must be continued to demonstrate that C. fimbriata is the primary pathogen.

A new species of Ceratocystis was found associated with a black canker of aspen, which is also common throughout aspen stands in Colorado and morphologically similar to the Nectria-like canker. Inoculation tests with the new species are planned to determine its relationship to canker formation.

Inoculotions demonstrote pothogenicity of Neopeckio coulteri

The ability of Neopeckia coulteri (Pk.) Sacc. to attack and kill vigorous current-year foliage covered by snow was demonstrated by inoculating lodgepole pine foliage in October 1963. Destruction of 1963 foliage did not involve invasion or injury of the twig, nor prevent its formation of the 1964 internode and foliage.

Thirty-two of 41 inoculated pine saplings exhibited typical snow mold injury (fig. D-1). In eight instances the snow mold spread from the inoculated foliage to nearby lateral branchlets. Of the paired controls (untreated and pseudo-inoculated) on the same trees, only one pseudo-inoculated branch showed evidence of slight snow mold injury (probably from natural inoculum sources in the study plot).

These positive results indicate that lodgepole pine snow mold may result from pathogenic activity, and that it is not necessarily restricted to saprophytic development of the fungus on senescent or smothered foliage material. Field observations suggest that the former mode of attack is at least as common as the latter.

Figure D-1.--Left, untreated control; center, inoculated branch on which the fungus has grown from point of inoculation to a nearby uninoculated branchlet; and right, a pseudo-inoculated control bound to a portion of healthy foliage with scotch tape.

Folioge diseose survey reveols new host-fungus combinotions

In a survey of coniferous foliage diseases, several organisms "new" to Colorado were collected. The most interesting was a highly distinctive needle cast fungus of ponderosa pine. This fungus, Lophodermium ponderosae Staley, displayed characteristics considered intermediate to Lophodermium and Hypodermella. Other new records included Coryneum cinereum Dearn. on ponderosa pine, Hypoderma robustum v. Tub. on white fir, Hypodermella arcuata Darker on limber pine, Hemiphacidium planum (Davis) Korf on ponderosa pine, Lophodermium decorum Darker on white fir, Lophodermium autumnale Darker on subalpine fir. The only widespread needle cast in Colorado during 1963 was Hypodermella concolor (Dearn.) Darker attacking lodgepole pine.

Root-knot nemotode found on ponderoso pine

A species of root-knot nematode, genus Meloidogyne, was found parasitizing the roots of mature ponderosa pine in southwestern New Mexico. Mature females were located in slightly swollen areas on the fine feeder rootlets (fig. D-2). No other report of the occurrence of root-knot nematode on ponderosa pine was found in the literature. Preliminary examination of the perineal patterns indicates that this may possibly be a new species. Tree symptoms included discolored needles and fading foliage. The symptoms progressed downward through the crown over a period of time.

Dothistromo needle blight of Austrion pine controlled with fungicides

Needle blight caused by the fungus, Dothistroma pini Hulbary, is widespread on Austrian and ponderosa pines in the central and southern Great Plains. Of several chemicals tested in eastern Nebraska, only Bordeaux mixture gave good control of the disease.

Figure D-2.--Female root-knot nematode parasitizing a ponderosa pine root.

Range Management and Wildlife Habitat Research

Thurber fescue requires ample moisture

Seedlings of Thurber fescue apparently are less drought resistant than seedlings of Idaho fescue, but they produce more herbage, especially with ample moisture.

To determine moisture requirements, recently germinated seed of Thurber and Idaho fescues were mixed and planted at different ratios in 5-gallon containers (fig. R-1). One group of seedlings was watered sufficiently once each week to raise moisture content of the surface 6 inches of soil to field capacity; the other group received half that much water. Data taken 10 months later indicate that young plants of Thurber fescue are less drought resistant and require more moisture for full development compared to Idaho fescue, but they produce more herbage:

	Watered	
	Most	Least
Thurber fescue:		
Survival (percent)	83	51
Herbage produced (grams per container)	61	22
Length of leaves (inches)	12.3	9.8
Basal diameter (inches)	.51	.40
Idaho fescue:		
Survival (percent)	76	83
Herbage produced (grams per container)	19	17
Length of leaves (inches)	9.2	7.3
Basal diameter (inches)	.27	.28

Survival was essentially the same for all planting ratios. Both species are important plants in mountain grasslands of the central Rockies.

Figure R-1.--Seedlings of Idaho and Thurber fescues were planted in various mixtures and watered at different rates to determine their ability to compete with one another and to withstand drought. The instrument in the container is a soil moisture tensiometer, which indicates relative dryness of the soil.

Nitrogen increoses productivity of mountain grossland soil

Productivity of mountain grassland soil from Black Mesa in western Colorado was increased nearly one-half by nitrogen fertilizer (ammonium nitrate) applied at a rate equivalent to 100 pounds per acre. Derived from andesite and related volcanic materials, this soil is generally considered to be quite productive.

Undisturbed soil collected from 1-acre areas in which pocket gophers had been excluded for 6 years and from comparable areas where gophers were present were about equally productive. These findings are based on herbage production of Moravian barley plants grown on representative soils in the greenhouse. Whether soil productivity is affected by the burrowing activity of pocket gophers, which may alter both structure and texture of the surface soils, is now being investigated.

What do sheep eat on alpine ranges?

Twenty-five kinds of plants were observed to have been grazed by sheep in 1963 on Carter Mountain in northwestern Wyoming (fig. R-2). Mat sedge, utilized 22 percent, was grazed more closely than any other plant. Next most heavily cropped were two clovers--whiproot and dwarf--18 and 17 percent, respectively. Tolmie and needleleaf sedges were grazed 13 and 10 percent. Use of 20 other plants averaged less than 10 percent.

Although four of the five species grazed most heavily are common components of alpine vegetation, other common plants, including bluegrasses, sheep fescue, alpine avens, and prairie Junegrass were grazed very little.

Greater profit from integrated use of seeded and native range

Integration of seeded ranges with native pine-bunchgrass ranges promises to be a practical and profitable livestock management system in the Front Range of the Rocky Mountains. In 1963, calves raised part time on native range and part time on ranges seeded with Russian wildrye, crested wheatgrass, and Sherman big bluegrass weighed an average of 17 pounds more per head when weaned November 15 than those raised on native range alone. At present native forage, supplemented with hay during winter, provides most of the feed for livestock in the area.

Calves raised under the integrated grazing system were worth $4.10 more per head at 1963 prices than those from native range. Sherman big bluegrass was primarily responsible for the weight differential at weaning time, since calves on both ranges weighed about the same in mid-October. Unweaned calves that grazed big bluegrass from October 16 to November 15 gained 1.75 pounds daily compared to 1.25 pounds for comparable calves that grazed native bunchgrass range. The cows gained 0.73 pound per day on bluegrass from October 15 to December 30, but lost 0.78 pound per day on native range. This difference may be reflected in later calf crops.

Figure R-2.--Sheep on this alpine range in northwestern Wyoming made good use of whiproot clover (inset) in 1963. Only mat sedge was grazed more closely.

Tips on root plowing shrub live oak

To be most effective in killing shrub live oak, the blade of a root plow should undercut all plants not less than 12 inches below the surface, according to findings near Prescott, Arizona. Severed from the root system at that depth, the root crown generally dies. Otherwise, it sprouts profusely and continues to grow.

To avoid missing plants between swaths, the operator should see that the plow overlaps the berm of soil along the edge of the adjacent swath. Plants within the berm are not cut in the initial operation.

To clear brush out of the plow, the operator ordinarily raises the blade and turns out of the swath being cut. Before continuing to plow he should drop the blade several feet to the rear of the point at which it was raised. This permits the blade to reach proper cutting depth before uncut brush is encountered.

Root plowing is one of the most effective means known for controlling shrub live oak, a common plant in Arizona chaparral. It is especially useful on fairly level areas with deep soil where forage production can be increased many times through brush control and grass seeding.

Forage utilization guides useful in gaging midseason grazing

Utilization guides based on the relationship between relative numbers of plants grazed and relative amount of herbage grazed have been developed in New Mexico for blue grama, Kentucky bluegrass, mountain muhly, and Arizona fescue (fig. R-3).

Because use of the guides is limited to periods during which grazed and ungrazed plants can be readily distinguished, and to ranges on which not all plants concerned have been grazed, they may prove most useful for estimating utilization midway in the grazing season. About 50 transects of 100 plants each are generally needed to provide a reliable basis for estimating utilization of a given species by this method on a range allotment with variable range types.

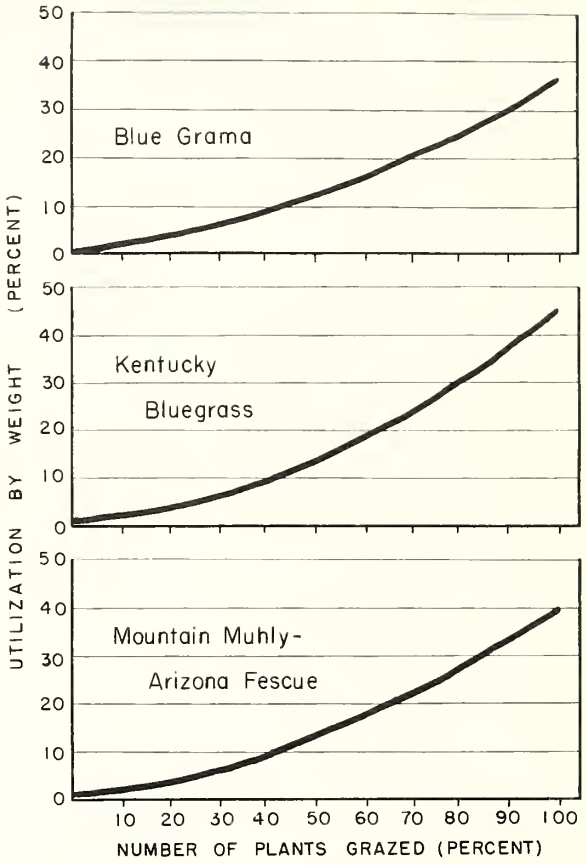


Figure R-3.--Utilization of these grasses can be estimated by counting numbers of grazed and ungrazed plants along representative range transects and interpreting findings from the curve for the species concerned.

In developing the curves for blue grama and Kentucky bluegrass, individual plants of which are difficult to distinguish, a 3-inch-diameter loop was used in classifying grazing use. If less than 5 percent of the herbage within this unit or that of individual plants of bunchgrass was missing, the plant unit was considered to be ungrazed. These guidelines must be followed to obtain reliable information from the curves shown.

Ignition of juniper hastened by chemical drying

Only 20 seconds were required to ignite juniper trees in which moisture content of

leaves and twigs had been reduced to 40 percent by spraying with monochloracetic acid several days prior to burning. This was one-seventh the time required to ignite unsprayed trees that contained about 75 percent moisture. Time required for ignition was cut in half by reducing moisture content of foliage to 60 percent.

To provide a range in moisture content of the foliage, trees were sprayed with chemical one to several days before they were ignited, thus allowing variable time for drying. Individual trees were set afire by holding a fusee next to the foliage (fig. R-4).

These tests were made in northern Arizona in cooperation with the Agricultural Research Service, U. S. Department of Agriculture, to develop and improve techniques for controlled burning in the pinyon-juniper type.

Figure R-4.--Juniper trees sprayed with chemical desiccant burst into flame much more quickly than similar trees that had not been sprayed in northern Arizona tests.

Grass-shrub cattle ranges can be improved by periodic deferment

By deferring grazing in alternate years until the end of the summer growing period and utilizing perennial grasses 40 percent, allowable stocking was increased 62 percent between 1954 and 1961 on two range units on the Santa Rita Experimental Range in southern Arizona. These benefits were obtained without killing mesquite. On two other units in which practically all mesquite were killed in 1954 and 1955, allowable stocking increased 169 percent over the 7-year period (fig. R-5).

The increases in stocking were equivalent to 8 and 17 head of cattle per section, respectively, on the mesquite-infested and mesquite-free units. Though summer rainfall varied greatly from year to year during the study, it showed no definite trend and apparently was not responsible for the improvement in range condition.

Figure R-5.--Grazing capacity of semidesert grassland, increased by alternate summer deferment and lighter grazing between 1954 and 1961, was further increased by mesquite control on the Santa Rita Experimental Range in Arizona.

These results indicate that grazing management alone can improve semidesert grass-shrub cattle ranges; when improved management is coupled with mesquite control, even greater increases in grazing capacity may be expected (fig. R-6).

Gross yield per inch of rainfall a useful index to productivity of southwestern ranges

Knowledge of the amount of grass produced per inch of summer rainfall has proved to be useful in evaluating the relative productivity

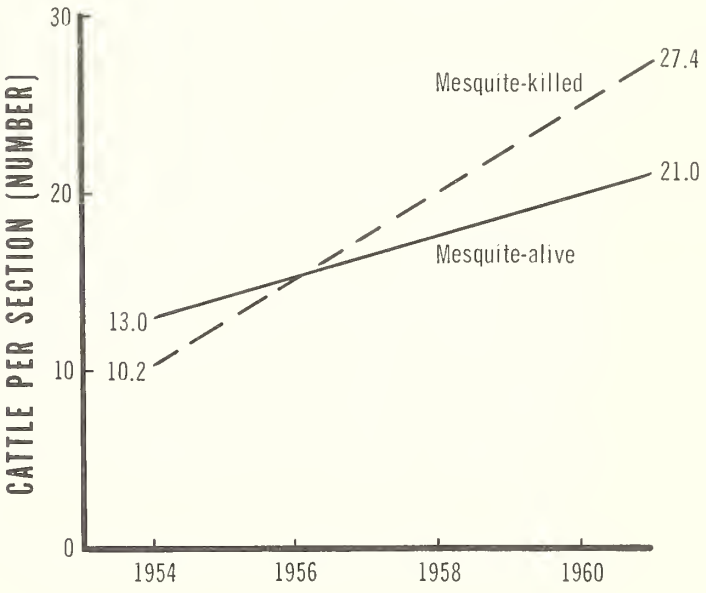


Figure R-6.--Left: Proper grazing and mesquite control were responsible for the high productivity of this semidesert range shown in 1961. Right: The same range in 1953 before range improvement practices were begun.

of two or more ranges, and in determining trend in production of a given range on the Santa Rita Experimental Range. Because production of perennial grasses on southern Arizona rangeland varies widely from year to year, not only with condition of the range but with the amount of rainfall received during the growing season, trend in range productivity is generally obscured. For example, from figure R-7 it is evident that the amount of grass produced per acre was much higher in 1958 than in 1954, and much lower in 1962 than in 1958, yet no trend in production is indicated. When the amount of grass produced each of the 3 years is expressed in pounds per acre per inch of summer rainfall, however, a definite upward trend in production is revealed.

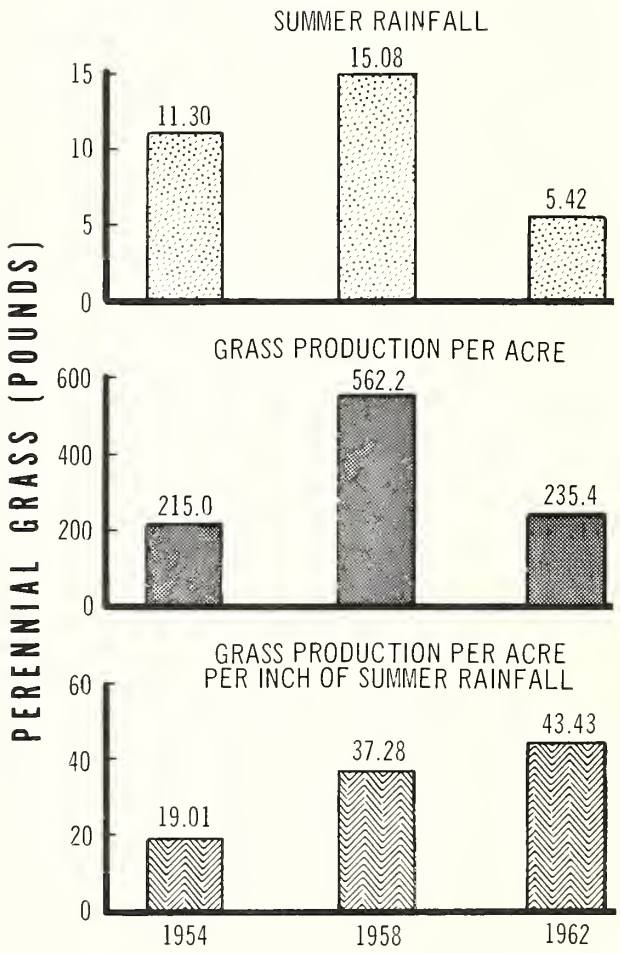


Figure R-7.--Production of perennial grass, expressed in pounds per acre per inch of summer rainfall, reveals upward trend in the productivity of a semidesert grassland.

Natural forest openings important elk habitat

In a selectively cutover ponderosa pine forest on the Apache National Forest in Arizona, where natural openings comprised 13 percent of the area, elk pellet groups--a good indicator of use--were nearly twice as numerous in natural openings as in the adjacent forest. Pellet groups became more numerous with distance from the forest edge to a point about 500 feet into the openings. At greater distances they became less abundant until, beyond 1,400 feet, none were found.

Within the forest, elk pellet groups tended to decrease with distance from the forest

Figure R-8.--Elk make relatively heavy use of natural forest openings in the Southwest, possibly because of the abundance and variety of forage that grows there.

edge. Nearly all were found within a quarter-mile of openings.

Although deer made relatively less use of forest openings than did elk, both may use openings 1 to 45 acres in size equally or more heavily than surrounding forest land The importance of forest openings as big game habitat may be due in part to the abundance and diversity of plants that commonly grow there (fig. R-8).

Burned-over choporrol provides deer browse

Sprouts of birchleaf cercocarpus were eagerly browsed by deer during spring and early summer in 1963 on a chaparral site in central Arizona that had been burned over the previous fall. By July more than 35 percent of current twig growth had been grazed. Common associated shrubs, Wright silktassel and shrub live oak, were browsed less than 10 percent at that time.

During fall, silktassel sprouts produced by summer rains were first to be utilized appreciably--more than 15 percent by late September. Birchleaf cercocarpus was browsed almost equally as much during October and November. Use of shrub live oak, however, was limited to about 5 percent, mainly in September. Deer made practically no use of these shrubs during winter.

Crude protein content was highest in sprouts of birchleaf cercocarpus, particularly young ones. It ranged from more than 20 percent in early spring to about 8 percent in midwinter.

Young sprouts of all species contained around 25 percent crude fiber in April 1963. By the following February fiber content had increased to 45 percent in shrub live oak, to 37 percent in birchleaf cercocarpus, and to 30 percent in Wright silktassel. These differences may account in part for differences in palatability of the three shrubs.

Abundance of mountainmahogany reloted to soil fertility

True mountainmahogany, a valuable food plant for big game, is distributed widely but unevenly within the extensive ponderosa pine type of the central Rockies. Studies in Colorado have shown that its abundance varies with the soil on which it grows. Granitic soil, widespread in the Rocky Mountains, has been found to support only one-sixth as many mountainmahogany plants as does a soil derived from Madison limestone. Further investigation revealed that density of mountainmahogany is related to soil fertility.

Relative fertility of four soils collected from the same vicinity in central Colorado was compared by measuring the yield of bar-

UNSPRAYED SPRAYED

Figure R-9.--Effectiveness of the repellent, TMTD, in reducing browsing by deer is revealed by these chokecherry plants.

ley grown in them under comparable conditions in the greenhouse.

Fertilization with nitrogen, phosphorus, and potassium increased the yield from limestone soils 4 to 6 times, and that from the less fertile arkose and granitic soils 9 to 20 times.

Repellents effectively protect shrubs from overbrowsing by deer

Improved ZIP (zinc dimethyl dithio carbamate cyclohexylamine complex in a Rhoplex base) and TMTD (tetramethyl thiuram disulfide in adhesive base) offer promise of protecting young shrubs from browsing by deer until the plants have grown large enough to provide browse in sizable quantity.

Each of these deer repellents, developed by the Denver Wildlife Research Laboratory, U. S. Fish and Wildlife Service, was sprayed in the fall on new shoots of randomly selected chokecherry and quaking aspen on heavily used winter deer range in the Black Hills of South Dakota. Current twig growth of plants sprayed with repellent was browsed very little during the ensuing winter (fig. R-9) compared with adjacent plants that were not sprayed:

	Chokecherry	Quaking aspen
	(Percent browsed)	
ZIP repellent	0.3	3.6
TMTD repellent	3.3	.6
No repellent	24.9	11.7

How long the repellents will remain effective is not known. Protection of young shrubs even for 1 winter may obviate the need for costly wire cages or deerproof fences in experimental plantings.

Watershed Management Research

Weather factors that create avalanches studied in Colorado

Each winter, snow avalanches endanger lives and property in the high mountains of the West (fig. W-1). Snow and avalanche data have been taken by U. S. Forest Service snow rangers for the past 15 years at Berthoud Pass, Colorado, to learn how to recognize and reduce avalanche hazard.

A study of snow and avalanche data taken during the winter of 1961-62 showed, that for slab avalanches involving snow that had been on the slopes less than 48 hours (direct-action slab avalanches):

1. All were preceded by 12 hours or more when the 6-hour average windspeed exceeded 17 m.p.h.
2. Sixty-three percent were released following new snowfalls that totaled less than 7 inches in depth.
3. All were released when the air temperature was less than 28° F.
4. Cohesion of the snow mass increased with a decrease in temperature.

Future research will include:

1. A study of the relationships between air mass properties and index properties of stable and unstable snow deposits in avalanche starting zones.
2. A study of the structure of major storm systems which precipitate large-scale climax avalanche cycles.

Figure W-1.--When avalanche danger is high, explosives are often used to stabilize the snow on steep slopes above mountain highways (left) and within ski areas (right). The snow may settle in place or it may avalanche as it did in these cases. Research can improve the accuracy of avalanche hazard evaluations by developing a better understanding of the physical and mechanical properties of the seasonal snow cover and of mountain weather patterns.

Figure W-2.--Snowdrift at Straight Creek Pass. Note the slope on the natural snowdrift in the foreground compared to that in the area behind the fence. (February 4, 1963 - looking south).

Alpine snow accumulation can be increased to improve summer streamflow

Work at Loveland Basin in Colorado has shown that vertical-slat snow fencing can increase net snow volume under certain conditions, which depend on location (figs. W-2, W-3):

1. The deep part of the natural drift is no more than three to four times the height of the fence downwind from the fence location. This distance can increase to 8 to 10 times at windy sites, especially if winds approaching the fence flow up a relatively smooth slope of 18 to 50 percent.
2. The gap below the fence will not clog with snow.

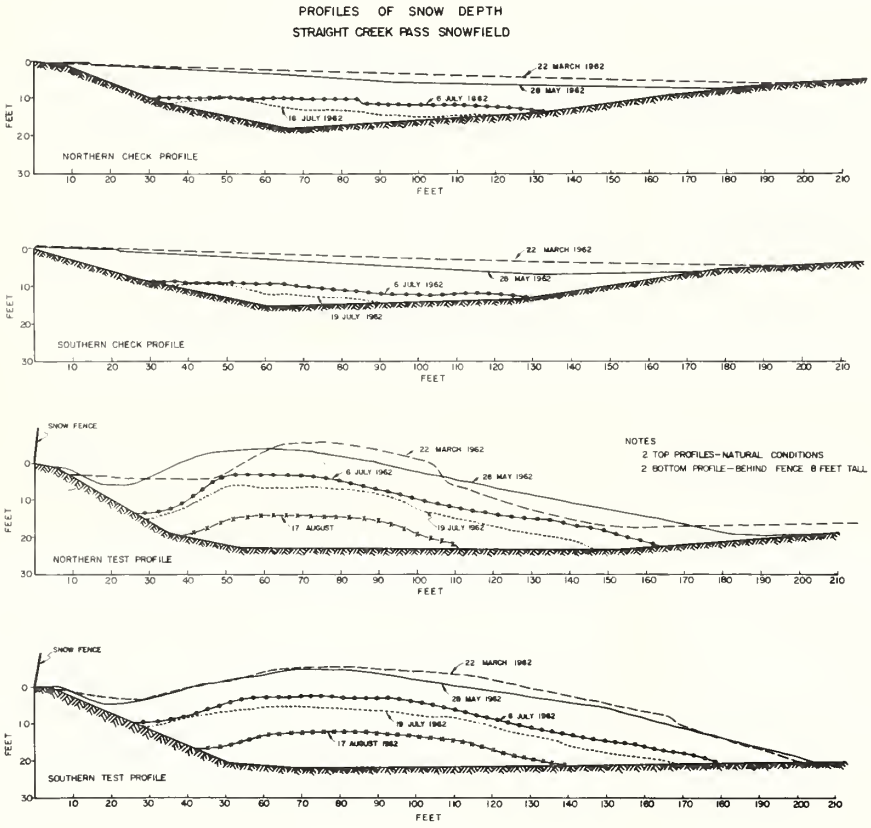


Figure W-3.--Profiles of April snow depths at Straight Creek Pass snowfield. During the winter of 1961-62, snow accumulation was increased 100 percent by April, and there was an extra acre-foot of water in the snowfield by mid-July for each 62.5 feet of fence. By mid-August all snow had disappeared from the control area, but there was still an acre-foot of water for each 122 feet of fence in the test field.

3. Windward surfaces are naturally smooth or are smoothed quickly by early snows. The windward area should slope uphill to the fence site for at least 100 yards. (The effective length of the windward area is not known.)
4. The late spring depth of the natural drift is 10 to 15 feet where the maximum fence effect is expected.
5. The direction of the drifting wind is consistent and there is a minimum of turbulence.

Vertical-slat snow fencing increased snow depths and net snow volume at three of the six test fields. Fences more than doubled the volume of snow in two of these fields, and increased it 50 percent at a third. At the other three fields, snow depths were increased close behind the fences but were decreased in other places, with no net increase in the amount of snow caught.

The size and location of the lee drifts formed by vertical-slat fences in the irregular alpine terrain fell within the limits published for such fences on level terrain.

Lee drifts usually had lengths 8 to 12 times the height of the fence (8-12 H). In steep terrain this length shortened to 7-8 H. The deepest part of the lee drift was located 3-5 H behind the fence in most cases, but, in a few cases, they were 8-11 H from the fence. The maximum height of the lee drift varied from 0.5-0.6 H at one field to 1.2-1.5 H at another.

Clearcutting increases snow accumulation in lodgepole pine in Wyoming

For average conditions in the Bighorn Mountains in Wyoming, clearcutting mature lodgepole pine in blocks of 5, 10, and 20 acres increased snow accumulation over that of uncut stands by 2.5 inches water equivalent, or about 40 percent. The greatest response to clearcutting was found on the east aspect, where the clearcut blocks accumulated an average of 3.2 inches more water equivalent than did the uncut area.

Under average conditions on south and east aspects, snow disappearance was similar on all clearcut blocks, with final snow disappearance preceding that of the uncut areas by 10 to 14 days. On northern exposures (fig. W-4) snow disappeared almost simultaneously from the clearcut blocks and the uncut stand. Snow persisted on a cut area longer than on an uncut area only on the west aspect where snowmelt period on the 20-acre block extended slightly beyond that of the uncut area, 5- and 10-acre blocks.

Basic research aims toward more complete understanding of watersheds

As watershed management research progresses, it becomes obvious that we must understand the intricacies of watershed behavior in order to extrapolate results of a given experiment to new areas. A series of current basic research studies (figs. W-5, W-6, W-7, W-8) should help give us the ability to prescribe a treatment for a particular watershed for optimum water production.

Figure W-4.--In areas of the Bighorn Mountains with a north-facing aspect, snow disappeared from the cutover blocks and uncut stand almost simultaneously. Snowmelt was uniform over the blocks with the exception of a narrow band adjacent to the western perimeters.

Figure W-5.--An instrument that makes it possible to obtain a relative estimate of water transpired by trees in their natural habitat. The instrument is fairly cheap, portable, and rugged. It has been field tested for 3 years with excellent results. It provides a relative index of sap velocity, and sap passing through a tree stem is a direct estimate of transpiration velocity. The latest model (pictured here) of the sapflow meter, gives a continuous weekly record of sap movement.

Figure W-6.--Moisture losses from the snowpack are determined from measurements of temperature in the soil, snow, and air above the snow; wind at various levels above the snow surface; and solar radiation at the snow surface. All of these measurements are continuously recorded in the instrument shelter.

Figure W-7.--Groundwater fluctuations in a small bog are being correlated to meteorologic measurements as part of studies to determine the hydrologic significance of the numerous bogs adjacent to many perennial streams in the mountains of Wyoming.

Figure W-8.--Soil moisture measurements by means of a neutron probe have been extended to include winter and spring months in order to compare the recharge and withdrawal of soil moisture under sprayed (2,4-D) and unsprayed big sagebrush cover in Wyoming.

Sediment movement is reduced by conversion of burned choporrol to gross

Establishment of a stand of introduced grasses and native forbs has reduced high sediment yields on the Three-Bar experimental watersheds in Arizona. A 1959 wildfire triggered heavy soil losses during the early postfire period. Chemical treatment to retard shrub growth, coupled with establishment of a vigorous stand of Lehmann, Boer, and weeping lovegrasses have improved soil stability compared to the adjacent untreated watershed. Movement of sediment from upper slopes and channel bottoms continues at a moderate rate on the untreated watershed, while sediment movement has virtually ceased under the heavy grass cover on the treated watershed.

Unrestricted shrub sprout growth on the untreated watershed has increased in six growing seasons to approximately 35 percent crown cover. Chemical control of shrubs on the other watershed has held shrub crown cover to only 5 percent, and release of grasses and forbs from competition has resulted in heavy herbaceous growth.

Amount of shrub live ook sprouting differs by seoson, but not by method, of top removol

On each of two spring and two fall dates, 60 individual shrub live oak bushes were selected and clipped to ground level. The bushes were divided into 10 replications, each consisting of 3 pairs. The stem bases of one member of each pair were burned. Later, when the five longest sprouts per bush averaged about 12 inches in length, one each of the three pairs was (1) sprayed with 4 pounds per acre of PGBE ester of silvex; (2) sprayed with 6 pounds per acre of the dimethyl amine salt of 2,3,6-TBA; or (3) left unsprayed.

Sprouts were counted at the time of chemical followup treatment. The sprouts were harvested and weighed the end of August, 14-1/2 months after the last spray application.

At the time of chemical followup, there was a significantly greater number of sprouts on plots where tops were removed during early fall (September 7), but no differences among other treatment dates. The difference between plots that were clipped only and those clipped and burned was not statistically significant.

At 14-1/2 months after chemical followup, fresh weight of sprouts from the two spring dates of top removal was more than twice as great as that from the two fall dates. There was no consistent difference between the two chemical treatments, but both reduced sprout weight to less than half that on the unsprayed plots. Weight of sprouts was nearly identical on the clipped plots and the clipped-and-burned plots, thus indicating that method of top removal before spraying was not important.

August 1956, after wildfire.

October 1961, shrub live oak dominates; herbaceous plants are scarce.

Figure W-9.--Typical shrub live oak chaparral on Mingus Mountain, elevation 5,000 feet.

Successianal changes in chaparral vegetation after wildfire--a rapid return ta prefire shrub cover

Chaparral crown canopy and total shrub weights were still increasing six growing seasons after a wildfire on Mingus Mountain, Arizona. Shrub live oak was the main component of the shrub community (68 percent) at this time.

Pointleaf and Pringle manzanitas and desert ceanothus plants were greatly reduced by the fire, but seedlings of these species were numerous within 5 years. Desert ceanothus seedlings outnumbered manzanita seedlings at the lower elevations (5,000 feet), but the reverse was true at higher elevations (6,500 feet) (fig. W-9).

Production of herbaceous species tended to be small except in one small area where shrub canopy was kept low by repeated chemical applications. On unsprayed plots, seeded and native grasses reached peak production in 1960, with about 200 pounds per acre at the higher elevations and 60 pounds per acre at lower elevations. On the sprayed area, production of weeping lovegrass alone exceeded 900 pounds per acre in 1961. Production of forbs reached a peak during the second and third growing season after the burn, and then rapidly declined.

Infiltratian is greater under chaparral shrubs than in apen areas between

Shrub live oak is the dominant species in Arizona chaparral. To examine the influence of oak on infiltration rates, the rates under shrubs were compared with those of the adjacent bare soil. Infiltration rates were determined by the ring infiltrometer method (fig. W-10).

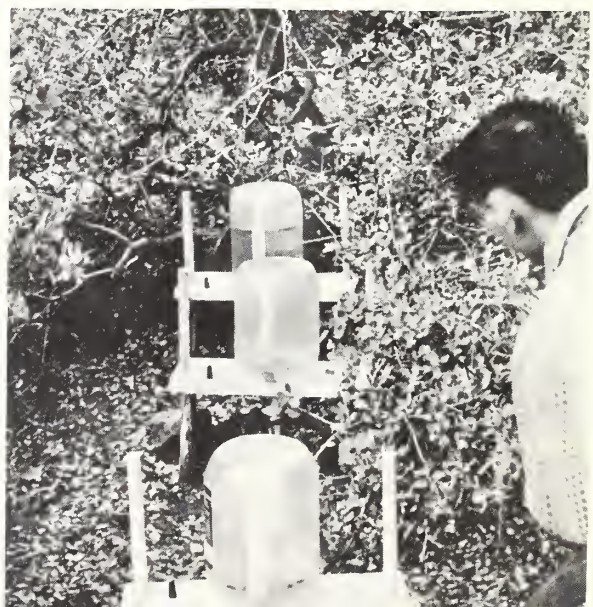


Figure W-10.--Positioning the infiltrometer setup. Water flows from the bottle through a tube to maintain a 1-inch head on the soil within the ring, inserted 4 inches into the soil. The branches were cut so that the under-shrub runs could be made. The furthermost unit is near-stem, followed by periphery, and in the foreground the open-run unit. In the analyses, the near-stem and periphery units were combined.

Infiltration rates under shrubs were significantly higher than rates on open soil. Infiltration rates are associated with large pores, litter content, and bulk density of the surface soil.

Inaccessible riparian vegetation surveyed aerially

A study was designed to test the value of high-quality aerial photographs of various scales in mapping inaccessible riparian vegetation. Data from a recently completed ground survey of a 35-mile ephemeral stream was compared to interpretations of the vegetation from aerial photographs to determine feasibility and accuracy of mapping vegetation directly from aerial photographs.

Standard photos used by the U. S. Forest Service of approximately 1:15,000 scale can be used to determine vegetation zones and area of riparian coverage. Photos of 1:12,000 scale suffice to determine channel widths and identification of some mature plants. Scale of 1:6,000 are excellent for identifying some of the dominant tree species, determining their height and percent of cover, and determining slope of channel and some channel characteristics. A 1:3,000 scale had the greatest detail and undoubtedly was the best scale used for species identification. However, even with the 1:3,000 scale only about 10 percent of perennial plants could be accurately identified in the upper reaches of the stream channel. Thus, use of the 1:3,000 scale is questionable for most mapping purposes because of the added cost of extra photos, and technical difficulties of getting undistorted pictures in mountainous terrain.

Gullies can be controlled mechanically

A total of 118 control structures and 4 grassed waterways have been installed on Alkali Creek in central Colorado, to determine proper design of mechanical treatments.

Several types of check dams, based partly on the success or failure of numerous historical control works in the Rocky Mountain area, are being tested in order to gain more understanding of the behavior of structures.

Loose rock check dams are used where rock is abundant, and the required structural heights are limited. Wirebound rock check dams are used where structural heights exceed several feet or where only small-sized rock is available.

Because rock and trained hand labor are not always readily available, and more elaborate check dams such as concrete crib dams require special equipment, a new type of prefabricated check dam was designed and is being tested in the field (fig. W-11). It consists of a total of nine concrete parts: three posts with attached foundation slabs, and six dam-wall slabs (including freeboards). Field installation is accomplished with a backhoe as the only piece of machinery.

Grass-covered waterways are a more economical means of controlling gullies (fig. W-12), but their effectiveness depends greatly on the successful establishment of adequate

Figure W-11.--During the snowmelt last spring, this prefabricated concrete check dam successfully withstood its most severe test, when the hydrostatic head of the waterflow and the saturated soil pressure of the sediment deposits acted simultaneously on the structure. Head of flow attained 0.5 foot, measured at the 19-foot-long spillway. The suspended sediment concentration of the water reached 20,000 p.p.m., and 150 cubic yards of sediment filled the catchment basin behind the dam to the 4-foot-high crest of the spillway.

Figure W-12.--Looking uphill into a former gully that has been partially filled and is being compacted by a roller. Before treatment the gully had a depth up to 8 feet and an upper width of 21 feet. Treatment on the headwater segment of the gully had been completed. The gentle swale on the right side of the upper disturbed area indicates the location of the upper part of the new waterway.

ground cover. The following design criteria have been applied:

1. Place waterway away from gully fill.
2. Replace top soils on cut and fill areas.
3. Provide greater channel width by forming a gentle, swaled cross section.
4. Where conditions permit, lengthen the watercourse in order to decrease the channel gradient.

A new low-cost flume for ephemeral streams

The need for accurate water-inventory data is particularly important as multiple use management of wildland resources intensifies. Designing a device to measure water yields from ephemeral streams with steep slopes, a wide range of flows (0.5 to 300 c.f.s.), heavy sediment and debris loads, and flows with supercritical approach velocities, presents challenging problems. Laboratory models were tested to select a device from several alternatives that would satisfy these needs. Concrete prototypes of a trapezoidal Venturi flume were built in 1957.

If these Venturi flumes are to receive wide use, however, they must be constructed of low-cost materials. Five flumes were therefore constructed that incorporate recent design modifications based on earlier field experience and the use of new materials (fig. W-13). To reduce costs, fiberglassed plywood panels, and steel support walls and intake boxes were prefabricated, hauled to the construction site, and assembled in place to test under field conditions.

Footings, cinder block walls, prefabricated steel frames, and prefabricated fiberglassed plywood sidewall panels make up the major components of the flume. Total cost is around $1,500 per flume: materials, about $500; labor, $800; and the recording instrument, $200. A finished flume was constructed with a 4-man crew in 10 days. The flume as built can handle flows up to 222 c.f.s., accompanied by high sediment loads. Diverging sections have been put on the flumes built in alluvium soils.

Figure W-13.--A modified trapezoidal flume made with prefabricated fiberglassed plywood. Dimensions are 5 feet wide in the approach section, constricting to 1 foot in the measuring section. Sidewalls are at 30° from the horizontal and the flume is on a 5 percent slope. Depth is 3 feet, which will accommodate a maximum discharge of 222 c.f.s.

Forest Economics Research

Evaluating multiple use effects of watershed treatments

One possibility to increase streamflow in the semiarid Southwest is to change the vegetative cover on upstream watersheds. Before attempting such practices, the effects of these treatments on other watershed values--timber, forage, wildlife, and recreation--must be determined. Also, if such practices are feasible, operational techniques must be developed. These can be done on a small scale by applying treatments on pilot watersheds where detailed records of products and costs are kept.

Evaluating the benefits of a large-scale program requires the collection of additional economic data about the particular river basins where such a program is contemplated. The pilot plant then provides a physical basis for evaluation, while the river basin studies provide an economic basis. Both must be harmonized to make the complete evaluation.

To have a beginning point for a multiple-use evaluation, a benchmark is needed from which to compare present products with those produced under new practices. It can be established by showing the pretreatment estimates of all of the product yields in the form of a product mix table (table E-1). A product mix table describes multiple use by spelling out the quantities of products that come from a particular area or class of land.

Table E-1.--Beaver Creek product mix from untreated areas, 1958-62[1]

Cover type	Average yield, by product							
	Water per acre	Forage-grass per acre		Timber per acre per year			Game	Hunter use
		Per year	Total					
	Inches	Pounds, air-dry		MBF	Cords	Cu. ft.	Acres/deer	Acres/hunter day
Ponderosa pine	5.0	100	190	[2] 44.5	[2] 0.16	[2] 33.5	--	--
Alligator juniper	3.1	190	450	--	--	1-3	--	--
Utah juniper	.4	20	205	--	--	2-4	--	--
Combined types	--	--	--	--	--	--	90	25-30

[1] Since all summaries in this table are based on less than 5 years' data (some from restricted parts of the watershed), this first approximation is crude. Records will be refined and expanded to make future comparisons more precise as the project continues.

[2] Watershed 12.

Comparison with posttreatment tables will show what is gained and sacrificed in multiple use terms for a redirection of management. Such comparisons form a physical basis for deciding alternative practices. For example, it may be desired to increase streamflow by a particular amount, and the pilot plant studies may suggest several ways to do this. A comparison of the product mixes for the several alternatives provides a basis for an appraisal of the advantages and disadvantages in physical product terms.

By comparing before-and-after product mixes, including posttreatment changes, generalizations can be measured. In a heavy clearing treatment, for example, water, sediment, and forage can be expected to increase, while ultimately timber production will decrease. Game habitat will be affected adversely for some species and favorably for others. Most of the resultant product mixes will not be static, but will change from year to year as the land adjusts to treatment. In the short run, greatly expanded timber harvests will increase economic activity, but finally timber must assume a lower level of activity.

Clearing juniper does not appreciably affect soil water storage

Clearing operations on Beaver Creek Watershed on Arizona's Mogollon Rim, have been underway since 1957 to improve forage and water yields.

This area experiences too distinct "wet" periods--a summer period from about July to September, and a winter period from about December to April. Soil-moisture sampling was emphasized at the beginning and ending of "wet" periods, or over the widest range of soil-water storage, and also during warmer months or "growing seasons," when soil-water differences between cleared and natural areas would presumably be more pronounced.

Results from 90 comparisons (10 plot pairs on 9 dates) show that slightly more water was stored on cleared plots for 75 of the 90 comparisons; differences were small, however.

These differences were not particularly related to the level of soil water, nor were they pronounced in the growing season or warmer months. One explanation may be that in September, cleared plots supported one to nine times as much ground cover as natural plots, which suggests that volunteer species keep soil water at the same level found in natural areas.

From a practical point of view, clearing in the Arizona juniper types may considerably increase water available for forage production, but have little effect on water yields insofar as they are influenced by soil water storage.

Strategic cutting tests in ponderosa pine

Fourteen watersheds in the ponderosa pine type are now being calibrated on Beaver Creek prior to management treatments intended primarily to increase water yields. Treatments are expected to include various types and intensities of forest thinning and strategic clearcuttings.

Preliminary tests of strip cuttings have been started this year to determine their desirability as a water yield improvement measure. The strip cutting is intended to reduce interception and evapotranspiration losses in the cut strips; also, surface runoff into the channels should be facilitated by the more or less continuous banks of snow leading downslope toward them. Of equal importance is the intent to hold snow through the winter so that it will melt relatively rapidly during a single period in March and April instead of piecemeal throughout the winter.

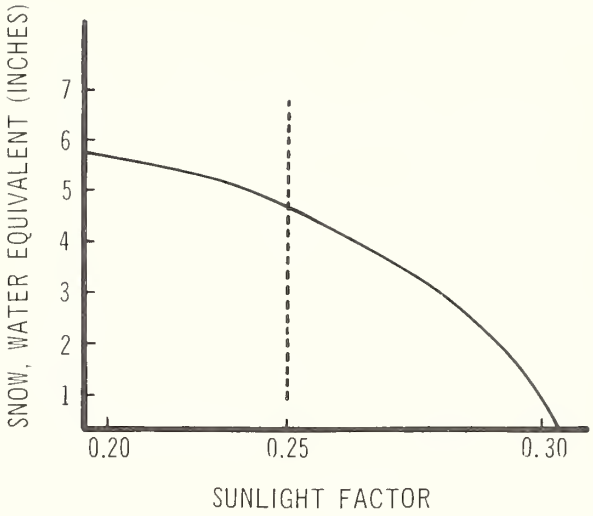
These objectives are being satisfied by locating the strips near natural channels and by orienting them (where possible) up-and-down the slope in an east-west direction.

Snow retention in thinned and uncut stands is being measured concurrently. Also, the timing of runoff from all three situations will be correlated with runoff in nearby major streams to learn whether runoff from "stored" snow actually gets into the streams.

"Sunlight factor" for predicting snow-storage potential

A part of the present strategic cutting tests is an attempt to identify the relationship between accumulated snow water equivalent and insolation. Once established, such a relationship could provide a basis for predicting the snow-storing potential of strips of different widths on sites with varying timber stocking, slope, and aspect (fig. E-1). The insolation parameter being used, called sunlight factor (SLF), is calculated from hemispherical canopy photos which are taken in the cut strips, and on which sun paths are plotted. A dot count of canopy-free sky is made along the sun path to obtain hits on open sky (H). H, multiplied by average percent of normal (90 degrees) insolation for the day (I), gives the SLF for the day. Thus, SLF = IH. The percent normal insolation values for different slopes and aspects have been tabulated by the Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

The amount of snow accumulated in the strips on March 5 appeared to be a reasonable function of average sunlight factor for the preceding 7 weeks, the relationship being:



To hold snow, then, the sunlight factor (which is the product of IH) must evidently be less than 0.25. This suggests that by solving the equation

$$H = \frac{0.25}{I}$$

for different values of I, we can predict the amount of canopy (H) in an uncut strip needed to hold snow in different parts of the adjacent cut strip for various slope-aspect combinations (I).

Figure E-1.--Clearcut test strips on Beaver Creek are being used to evaluate differences in snow accumulation and melt rates caused by the orientation of the strip, strip width, and topographic shading. The "leave" strip on this west-facing slope has been effective in holding most of the winter snowfall (about 5 inches water equivalent) in a band 1.5 tree heights wide.

Forest Biology Research

(In cooperation with the Fish and Wildlife Service, U. S. Department of the Interior)

Population of mountain pocket gophers predictable from counts of ground surface forms

A significant relationship was found between number of fresh ground surface forms (mounds and earth plugs) made in a 48-hour period and the number of mountain pocket gophers (Thomomys talpoides) present on a series of test plots (fig. B-1). The relationship (fig. B-2) provides a basis for estimating mountain pocket gopher populations on the areas tested.

The method was tested over a 3-year period in late August and early September, a time when mound building by pocket gophers tends to be at a peak level. The work was done on mountain rangeland at 10,000 feet elevation on Black Mesa Experimental Forest and Range and on Grand Mesa in western Colorado.

Figure B-1.--Mounds are made by pocket gophers as they evacuate soil in extending and cleaning their underground burrow systems. Holes are plugged with dirt when the gophers return to their burrows after feeding aboveground.

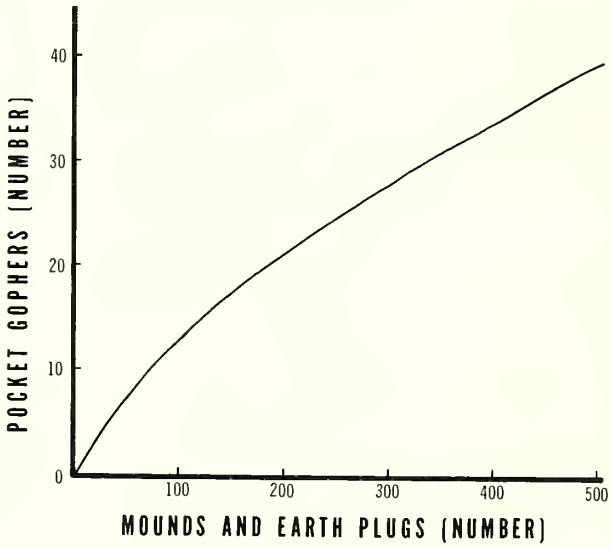


Figure B-2.--The relationship, per 40,000 square feet, of ground surface forms to number of mountain pocket gophers.

Mountain pocket gopher population similar under three grazing intensities

A population of mountain pocket gophers was not influenced by light, moderate, or heavy summer cattle grazing on mountain rangeland in western Colorado. The population showed two peaks and a major decline in an 8-year period. These fluctuations in population were similar for the three grazing treat-

ments, however, which indicates that, for the period of sampling, grazing treatments had not influenced the population differently.

The mountain pocket gopher population was approximated each year from trap outs of sample plots and counts of earth surface forms made by the animals in early September.

Mountain pocket gophers more abundant than montane voles on mountain rangeland

The mountain pocket gopher has been more abundant than the montane vole (Microtus montanus) over the past 8 years on mountain grassland range grazed in summer by cattle. Population trends for the two species have been similar. In years of peak population--1958 and 1963--pocket gophers averaged 28 and 20 animals per acre, respectively, while montane voles averaged only 4 per acre (fig. B-3). Even in years of low population, the gopher was more abundant than the vole. If interspecific strife exists between these animals on coinhabited range, the gopher seems to be much the dominant species.

Because the peaks and lows in population for both species occurred in the same years, it appears that the factor or factors that regulate these fluctuations are the same for both animals on this type of range. The mountain pocket gopher and montane vole coinhabit Thurber fescue-forb range on the Black Mesa Experimental Forest and Range, and both species rely on existing grass, forb, and shrub plant material for food, cover, and nesting material (fig. B-4).

Rabbits more abundant on ungrazed watershed in salt-desert shrub type

Blacktailed jackrabbits (Lepus californicus) were more abundant on an ungrazed watershed than on an adjacent grazed watershed at about 5,000 feet elevation in the salt-desert shrub type at the Badger Wash Experimental area in western Colorado. In a drive on a 101-acre watershed, protected from livestock grazing for a 9-year period, men counted 14 blacktailed jackrabbits. The approximate population was one animal to 7 acres. On an adjacent 107-acre watershed grazed in winter by both sheep and cattle, only one jackrabbit was flushed.

The drive count substantiated findings from counts of jackrabbit droppings on permanent sample plots.

Desert cottontails (Sylvilagus audubonii) were also more abundant on the ungrazed watershed, but only three cottontails were counted on the drive in the ungrazed watershed, an approximate population of one animal to 33 acres. None were flushed on the grazed watersheds.

The inventory suggests that the taller, more fully crowned plant cover on the ungrazed watersheds makes more favorable habitat for blacktailed jackrabbits and desert cottontails, and that, in this particular case, grazing tends to hold these animals at a lower population level.

Figure B-3.--The live trap, mark, and release method of inventory was one of the techniques used to follow population trends of montane voles on grazed range.

Figure B-4.--Thurber fescue clipped by mountain pocket gopher for nest material. Note entrance of burrow system near center of clipped bunchgrass.

Publications

Timber Management and Forest Fire Research

Alexander, Robert R.
Minimizing windfall around clear cuttings in spruce-fir forests . Forest Sci. 10:130-142, illus.
A study of 234 clearcut units on 15 areas in Colorado identified many situations where windthrow hazards were above and below average, and recommends cutting boundary location practices. Topographically accelerated winds may cause exceptional hazards.

Boldt, Charles E., and Singh, Teja.
Root development of ponderosa pine transplants at Lincoln, Nebraska. U. S. Forest Serv. Res. Note RM-20, 4 pp., illus.
Although forest-planted pines probably wouldn't extend their roots so rapidly as those excavated in this study, results demonstrate entire planting areas must be cleared of vegetation if transplants are to be grown free of competition for only a few years.

Dawson, David H.,* and Read, Ralph A.
Guide for selecting superior trees for shelterbelts in the Prairie Plains. U. S. Forest Serv. Res. Paper LS-13, 22 pp., illus.
Discusses important desirable characteristics of 17 deciduous and coniferous species of trees used in shelterbelts. Defines and illustrates traits such as growth rate, crown density, width of crown, angle of branching, time of flushing and defoliation, straightness of stem, resistance to drought, winter injury, insect infestations, and disease.

*Private, State, or Federal cooperator.

Glock, Waldo S.,*Gaines, Edward M.,* and Agerter, Sharlene.*
Soil-moisture fluctuations under two ponderosa pine stands in northern Arizona. U. S. Forest Serv. Res. Paper RM-9, 34 pp., illus.
Four years of readings showed wide variation in the root zone, commonly more than one cycle per year. Fluctuations were greater and more rapid in dry years; infiltration and percolation occurred within hours or days.

Minor, Charles O.*
Site index curves for second-growth ponderosa pine in northern Arizona. U. S. Forest Serv. Res. Note RM-37, 8 pp., illus.
Conventional height-age relations were developed by individual tree stem analysis. Total height of dominants only was used. Age at breast height proved more stable and usable than total age. No effect of stand density on height growth could be shown for the trees sampled.

Myers, Clifford A.
Merriam's classification of the ponderosa pine forest in relation to current knowledge. Plateau 37: 67-72.
Merriam's definition of the ponderosa pine forest as a transition between boreal forest and arid zones is still valid. His temperature-based explanation of zonation has been expanded, principally to include amount and availability of moisture.

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Taper tables, bark thickness, and diameter relationships for lodgepole pines in Colorado and Wyoming. U. S. Forest Serv. Res. Note RM-31, 6 pp.
Presents tools for estimating: (1) diameter inside bark at various heights, (2) bark thickness at breast height, (3) past diameter from present diameter and radial wood growth, and (4) diameter at breast height from stump diameter.

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Volume tables and point-sampling factors for lodgepole pine in Colorado and Wyoming. U. S. Forest Serv. Res. Paper RM-6, 16 pp.

Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to an 8-inch top, and board feet International 1/4-inch Rule to an 8-inch top. Tree heights are in feet and numbers of logs. Volume equations are of the form $V = a + bD^2H$.

_____
Volume tables and point-sampling factors for ponderosa pine in the Black Hills. U. S. Forest Serv. Res. Paper RM-8, 16 pp.

Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to an 8-inch top, and board feet International 1/4-inch Rule to an 8-inch top. Tree heights are in feet and numbers of logs. Volume equations are of the form $V = a + bD^2H$. Volumes per square foot of basal area are also included.

Read, Ralph A.
"Hybrid" pines, a matter of time, patience, research. Nebr. Agr. Expt. Sta. Quart. 10(4): 10-12, illus.

Ponderosa pine in natural stands in and near the Great Plains is being studied to determine genetic variation and to locate better adapted sources for Plains planting. Over 50 stands from Montana and southwest North Dakota southward to New Mexico and west Texas will be avaluated.

_____
Tree windbreaks for the Central Great Plains. U.S. Dept. Agr. Agr. Handb. 250, 68 pp., illus.

Recounts past and present knowledge of the influences and benefits of windbreaks, and gives practical recommendations on species, arrangements, spacing, land preparation, planting stock, planting methods, cultivation, protection, and management for tree windbreaks in the central Great Plains of the United States.

Van Haverbeke, David F.
Shelterbelt research in Nebraska. Nebr. Agr. Expt. Sta. Quart. QR-91: 17-18, illus.

Conifers respond when released from suppression of deciduous species; deciduous species respond from crowding by removing alternate rows. Sprouts from cut trees and natural seedlings restore density to damaged plantings. Spacings, species combinations, and fertilizers are being tested in single-row plantings; seedlings are being planted in damaged shelterbelts.

Forest Utilization Research

Barger, Roland L., and Ffolliott, Peter F.
Specific gravity of Arizona Gambel oak. U. S. Forest Serv. Res. Note RM-19, 2 pp.

Mean specific gravity determined from breast-high increment cores is 0.634 (green volume, ovendry weight). Approximate charcoal recovery of 1,000 pounds per cord could be expected.

_____ and Fleischer, Herbert O.*
New products from low-grade ponderosa pine timber. U. S. Forest Serv. Res. Paper RM-10, 54 pp., illus.

Demonstrates the technical feasibility of producing types of plywood, particle board, overlaid siding, laminated beams, and laminated flooring. Products and manufacturing procedures either circumvent or tolerate the range of defect common in low-grade ponderosa pine sawtimber.

Landt, E. F.
Knife action and storage loosen bark on ponderosa pine pulp chips. U. S. Forest Serv. Res. Note RM-28, 4 pp.

Over 90 percent of the bark on slabs, edgings, and thinnings was loosened during chipping. The most effective storage condition subsequently loosened only one-fifth of the remaining bark.

_____ and Woodfin, R. O., Jr.
Sawmill and logging residues from ponderosa pine trees in the Black Hills. U. S. Forest Serv. Res. Note RM-23, 8 pp., illus.

The production of 1,000 board feet of lumber results in 1,150 to 1,650 pounds (ovendry) of chippable sawmill residue, plus 1,230 pounds of chippable logging residue--tops and cull logs. From woods through mill, 21 to 23 percent of the tree ends up as lumber.

Forest Insect Research

Chansler, John F.
Overwintering habits of Ips lecontei Sw. and Ips confusus (Lec.) in Arizona and New Mexico. U. S. Forest Serv. Res. Note RM-27, 4 pp.

Ips lecontei and I. confusus overwintered as adults in feeding colonies beneath the bark of ponderosa and pinyon pines, respectively. I. lecontei was found more frequently in stems under 9 inches in diameter, with maximum density between 5 and 10 feet aboveground. I. confusus densities were highest at or near ground line.

McCambridge, W. F.
Emergence period of Black Hills beetle from ponderosa pine in the central Rocky Mountains. U. S. Forest Serv. Res. Note RM-32, 4 pp., illus.

Illustrates the rate of beetle emergence and discusses the influence of temperature on emergence. Describes methods for determining emergence for use in control planning.

_____ and Pierce, D. A.
Observations on the life history of the pinyon needle scale Matsucoccus acalyptus (Homoptera, Coccoidea, Margarodidae). Ent. Soc. Amer. Ann. 57: 197-200, illus.

Describes life history and habits of pinyon needle scale from observations made at Grand Canyon and Mesa Verde National Parks. Differences in development between the male and female are covered.

Massey, Calvin L.
The nematode parasites and associates of the fir engraver beetle, Scolytus ventralis LeConte in New Mexico. Jour. Insect Path. 6: 133-155, illus.

Two internal nematode parasites kill adult beetles; their life histories are closely synchronized with that of the host. The host died (in lab studies) before it deposited eggs. One new genus and nine new species of nematodes found associated with the beetle are described.

_____ Two new species of the nematode genus Ektaphelenchus (nematoda: Aphelenchoididae), parasites of bark beetles in the southwestern United States. Helmin. Soc. Wash. Proc. 31: 37-40, illus.

Two new species of nematodes were recovered from beneath the wing covers of several bark beetle species in Arizona and New Mexico. Nematodes of the genus Ektaphelenchus are, for the most part, external parasites of bark beetles that occur in small cocoons beneath the elytra.

Nagel, R. H.

Preventing metal corrosion from emulsifiable ethylene dibromide packaged for bark beetle control. U. S. Forest Serv. Res. Note RM-26, 2 pp.

Epichlorohydrin, added to the dibromide concentrate, prevented corrosion of tin-plated storage containers for a 7-year period; without the inhibitor, the containers corroded in 6 months.

Forest Disease Research

Davidson, R. W.,* Hinds, T. E., and Toole, E. R.*

Two new species of Ceratocystis from hardwoods. Mycologia 56: 793-798, illus.

Ceratocystis tremulo-aurea Davidson and Hinds was found associated with black cankers of aspen in Colorado. C. megalobrunnea Davidson and Toole was isolated from sapwood of Nuttall oak in Mississippi. Little is known of host relationship or method of dissemination for either species.

Gill, Lake S., and Hawksworth, Frank G.

Dwarfmistletoe of lodgepole pine. U.S. Dept. Agr. Forest Pest Leaflet 18, 7 pp., illus. (Revised.)

Discusses the hosts, life history, spread and intensification, ecology, effects on hosts, and control of the lodgepole pine dwarfmistletoe.

Hawksworth, Frank G., and Hinds, Thomas E.

Effects of dwarfmistletoe on immature lodgepole pine stands in Colorado. Jour. Forestry 62: 27-32, illus.

Summarizes the effects of Arceuthobium americanum in 25 stands. The amount of damage is most closely related to time since infection; acceptable volumes cannot be expected in stands that become infected when they are young.

_____ and Wiens, Delbert.*

The Mexican species of Arceuthobium. (Abstract.) Amer. Jour. Bot. 51: 688.

Thirteen dwarfmistletoes are recognized from Mexico including five which also occur in the United States and five which were previously undescribed. At least 19 species of pines, as well as Abies and Pseudotsuga, are attacked by these parasites in Mexico.

_____ and Wiens, Delbert.*

A new species of Arceuthobium from Arizona. Brittonia 16: 54-57, illus.

Dwarfmistletoe that occurs on Chihuahua pine in Arizona and northern Mexico, described as a new species, is named A. gillii in honor of Dr. L. S. Gill, former Chief, Division of Forest Disease Research, this Station.

Hinds, T. E.

Distribution of aspen cankers in Colorado. U. S. Agr. Res. Serv. Plant Dis. Rptr. 48: 610-614, illus.

A survey of 4,075 trees on five National Forests in Colorado revealed that aspen cankers are distributed throughout the major aspen stands and are more prevalent than previously suspected. Sooty-bark canker is most damaging; status of hypoxylon canker remains questionable.

Lightle, Paul C., Wiens, Delbert,* and Hawksworth, Frank G.

Low-temperature injury to Phoradendron in Arizona and New Mexico. Southwest Nat. 8: 204-209.

Reviews the literature on cold damage to mistletoe. Describes cold kill of Phoradendron californicum over a wide area in southern Arizona and cold damage to three other species of leafy mistletoes in Arizona and New Mexico. Indicates probable critical temperatures for cold damage to these species.

Peterson, Glenn W.

Diseases of conifers in Nebraska. Amer. Nurseryman 118: 71.

Describes four important diseases of conifers in Nebraska and gives control methods.

_____ Dutch elm disease in Nebraska. U. S. Agr. Res. Serv. Plant Dis. Rptr. 48: 781.

Dutch elm disease, first reported in Nebraska in 1960, had been found in nine southeastern counties by the end of 1963.

_____ Hardwood diseases in Plains forest tree nurseries. Region 8 [U.S. Forest Serv.] Forest Nurserymen's Conf. Proc. 1964: 145-147.

Summarizes results of past and current investigations of hardwood diseases of Plains nurseries.

_____ Heat treatment of nematode-infested eastern redcedar roots. U. S. Agr. Res. Serv. Plant Dis. Rptr. 48: 862.

Heating roots of transplant stock in water at 52° C. for 2 minutes killed root-lesion nematodes (Pratylenchus penetrans); was least damaging to healthy roots.

Riffle, Jerry.

Root-knot nematode on African bermudagrass in New Mexico. U. S. Agr. Res. Serv. Plant Dis. Rptr. 48: 964-965, illus.

A species of root-knot nematode, genus Meloidogyne, was found parasitizing African bermudagrass, Cynodon transvaalensis, at Albuquerque, New Mexico, in July 1963. The grass in infested areas was thin, chlorotic, and dying out in spots. This host-parasite combination has not been reported previously in New Mexico.

Staley, John M.

A new Lophodermium on ponderosa pine. Mycologia 56: 757-762, illus.

Lophodermium ponderosae, the cause of a needlecast of Pinus ponderosa in Colorado, exhibits characters intermediate to those of the genera Lophodermium and Hypodermella. An unusually distinct species, it must either be restricted in range or fruit seldom to have escaped description.

_____
A survey of coniferous foliage diseases (other than rusts) in Colorado. U. S. Agr. Res. Serv. Plant Dis. Rptr. 48: 562-563.
Lists previously reported fungi and establishes records for new organisms found during the 1963 survey. Foliage diseases were encountered more frequently than expected.

Range Management and Wildlife Habitat Research

Arnold, Joseph F.*
Zonation of understory vegetation around a juniper tree. Jour. Range Mangt. 17: 41-42, illus.
Differences in floristic composition and herbage production within four eccentric zones are ascribed to differences in available soil moisture and sunlight.

_____,* Jameson, Donald A., and Reid, Elbert H.
The pinyon-juniper type of Arizona: effects of grazing, fire, and tree control. U. S. Dept. Agr. Prod. Res. Rpt. 84, 28 pp., illus.
Includes information on characteristics of the pinyon-juniper type, tree invasions and increases, effects of tree increases on other plants, principal methods used to control pinyon and juniper, response of vegetation to tree control, and costs and resulting benefits of control.

Cable, Dwight R., and Martin, S. Clark.
Forage production and stocking rates on southern Arizona ranges can be improved. U. S. Forest Serv. Res. Note RM-30, 11 pp., illus.
Rainfall, management, and mesquite control were major factors affecting grass production on four range units in southern Arizona. Year-to-year rainfall changes accounted for about 39 percent and 50 percent of the variation in perennial grass and annual grass production, respectively. Moderate (40 percent) use and alternate-year summer deferment roughly doubled production of perennial grasses in 5 years. Compared to mesquite-infested range, perennial grass production on mesquite-free range increased 223 pounds per acre in 5 years and calculated stocking for 40 percent use increased 10 percent per year.

Jameson, Donald A.
Effect of defoliation on forage plant physiology. In Forage plant physiology and soil-range relationships. Amer. Soc. Agron. ASA Spec. Pub. 5: 67-80.
Reviews literature on the effect of defoliation on plants and the physiological bases for these effects. Points out opportunities for research in applying known physiological principles to studies of defoliation and harvesting.

_____ and Johnsen, Thomas N., Jr.
Ecology and control of alligator juniper. Weeds 12: 140-143, illus.
Alligator juniper sprouts from stems, roots, or especially from buds on the crown, when the top is destroyed. For adequate mechanical control, the root crown must be removed from the soil. Treatment of stumps with pelleted fenuron or PBA spray are promising means of preventing sprouting.

Johnson, W. M.
What do sheep eat on alpine ranges? Wyo. Wool Grower 37(11): 30-31, illus.
In 1963, sheep on Carter Mountain in Wyoming grazed 25 different kinds of plants; most heavily grazed were mat sedge, whiproot clover, dwarf clover, Tolmie sedge, and needleleaf sedge.

_____ and Reid, Elbert H.
Range condition classification of bunchgrass range at the Manitou Experimental Forest in Colorado. Jour. Range Mangt. 17: 137-141, illus.
The relationship between various measurements by Parker's loop method and production of herbage was investigated. A good relationship was found between weight of herbage produced by desirable forage plants and percent cover of desirable plants and leaf height of mountain muhly.

Klipple, Graydon E.
Early- and late-season grazing versus season-long grazing of short-grass vegetation on the Central Great Plains. U. S. Forest Serv. Res. Paper RM-11, 16 pp., illus.
A system in which cattle grazed half the range during the first half of the summer, then were moved to the other part of the range for the remainder of the season year after year, was generally inferior to that of continuous season-long grazing at a moderate rate.

Pearson, Henry A.
Beef -- trees -- or both. Ariz. Cattlelog 20(7): 8-10, illus.
Describes a study designed to compare cattle production from ponderosa pine forests when thinned to different degrees and when clear cut. Effects of tree overstories on understory forage production, utilization and digestibility, beef production, and tree production are being evaluated.

Pond, Floyd W.
Response of grasses, forbs, and halfshrubs to chemical control of chaparral in central Arizona. Jour. Range Mangt. 17: 200-203, illus.
Within 5 years after treatment, grass cover and production increased markedly on quartzite soils, but not on diabase soils. Halfshrubs increased on both soils; most on diabase. Forbs showed little change on either soil.

_____
Toward more successful rootplowing. Ariz. Cattlelog 21(3): 18, 22, illus.
Root plowing is an effective way to eliminate shrubs such as shrub live oak to promote production of grass. Careful attention to details of the root plowing job improves the kill of shrubs.

Reynolds, Hudson G.
Elk and deer habitat use of a pinyon-juniper woodland in southern New Mexico. N. Amer. Wildlife and Nat. Resources Conf. Trans. 29: 438-444, illus.
Livestock range improvement can be coordinated with deer and elk habitat preservation by confining clearing of pinyon-juniper to slopes of less than 15 percent, and leaving existing cover on northeastern exposures. Elk and deer habitat might be improved by thinning trees which overtop shrubs where trees exceed about 150 trees per acre.

_____ Fort Bayard habitat improvement. N. Mex. Wildlife 9(3): 10-11, illus.

Elk and deer were found to prefer similar but specific sites within pinyon-juniper habitat. Heaviest use was on northeast exposures; lightest, on level sites. Slopes in excess of 15 percent were used as heavily as more level topography. In general, habitat use was related to abundance of birchleaf mountainmahogany and Wright silktassel.

_____ and Johnson, R. Roy.*

Habitat relations of vertebrates of the Sierra Ancha Experimental Forest. U. S. Forest Serv. Res. Paper RM-4, 16 pp, illus.

Describes the Experimental Forest in general terms, characterizes the more important vertebrate habitats, and presents a checklist of vertebrates together with notes as to their relative abundance, seasonal occurrence, and macro- and microhabitats. Includes 125 birds, 33 mammals, 24 reptiles, 3 amphibians, and 2 fish.

Schuster, Joseph L.

Root development of native plants under three grazing intensities. Ecology 45: 63-70, illus.

Describes and compares root systems of several grasses and forbs on ponderosa pine-bunchgrass ranges in Colorado that had been grazed at different intensities for 17 years.

_____ and Wasser, C. H.*

The nail-board method of root sampling. Jour. Range Mangt. 17: 85-87, illus.

Describes a method for excavating, exposing, and examining plant root systems, essentially in their natural position, through use of a nail-studded sheet of plywood and accessory equipment.

Springfield, H. W.

Some factors affecting germination of fourwing saltbush. U. S. Forest Serv. Res. Note RM-25, 8 pp., illus.

Germination of seed collected from eight sources in Arizona and New Mexico varied with source, but whether due to geographical location or environmental conditions was not clear. Seeds germinated better at temperatures within the range of 40° to 60° F. than at temperatures of 70° F. or higher.

_____ and Peterson, Geraldine.

Use of the grazed-plant method for estimating utilization of some range grasses in New Mexico. U. S. Forest Serv. Res. Note RM-22, 6 pp., illus.

The guides, developed on National Forest grazing allotments in 1961-62, give reasonably precise estimates of utilization up to 40-45 percent utilization by weight for blue grama, Kentucky bluegrass, mountain muhly, and Arizona fescue.

Watershed Management Research

Aldon, Earl F.

Ground cover changes in relation to runoff and erosion in west-central New Mexico. U. S. Forest Serv. Res. Note RM-34, 4 pp.

Sediment production decreased between 0.2 and 0.7 acre-foot per year after three watersheds were changed to summer-deferred grazing (aimed at 55 percent utilization by weight of alkali sacaton). Ground cover doubled, bare ground decreased, and runoff stayed about the same compared with a previous period of yearlong grazing.

Bergen, James D., and Swanson, Robert H.

Evaporation from a winter snow cover in the Rocky Mountain forest zone. West. Snow Conf. Proc. 32: 52-58.

Energy balances of snow cover for nine 12-hour periods in February and March are computed from measurements of snow temperatures, densities, and boundary fluxes of sensible heat and radiation. Evaporation, which depends on net insolation, ranges from condensation gains of 31 mg/cm^2 to losses of 180 mg/cm^2 per period.

Berndt, H. W.

Inducing snow accumulation on high windswept plains in southeastern Wyoming. Jour. Soil and Water Conserv. 19: 196-198, illus.

This progress report on studies of snow fence placement to limit snow movement by wind on watersheds in Wyoming reveals that there is no significant difference in the amount of snow trapped between fences spaced at intervals of 175, 250, and 325 feet during a winter of average snowfall.

Campbell, C. J.

Compact field kit for aerial photographic interpretation. Jour. Forestry 62: 266-267, illus.

An inexpensive kit, designed to hold 9- x 9-inch photos so that any portion may be viewed in stereo with a lens (pocket) stereoscope, is useful for field or office. Necessary equipment can be carried inside the kit.

_____ and Dick-Peddie, W. A.*

Comparison of eighteen phreatophyte communities on the Rio Grande in New Mexico. Ecology 45: 492-502, illus.

Compares, classifies, and interprets present composition of river-bottom communities along 300 miles of the Rio Grande in New Mexico. The narrow band of vegetation changed gradually from north to south.

_____ and Strong, J. E.

Salt gland anatomy in Tamarix pentandra (Tamaricaceae). Southwest Nat. 9: 232-238, illus.

Salt glands in T. pentandra are distinct structures composed of eight cells. The glands excrete salt solutions through a single pore during relatively high humidity conditions.

Davis, Edwin A.

Picloram: a promising brush control chemical. U. S. Forest Serv. Res. Note RM-35, 2 pp.

On the basis of preliminary greenhouse studies, picloram (4-amino-3, 5, 6-trichloropicolinic acid) shows considerable promise as a brush control chemical in Arizona. It appears that application to the soil around shrub live oak would be more effective than foliar application.

Decker, J. P., and Skau, C. M.

Simultaneous studies of transpiration rate and sap velocity in trees. Plant Phys. 39: 213-215, illus.

Sap velocity, measured with a heat pulse meter, appears to be a reliable indicator of (1) direction of rapid change in transpiration rate, measured with a tent apparatus, and of (2) both direction and magnitude of gradual changes.

Fletcher, Herbert C.
Weather, water, and research. In Research--the key to the future in water management. N. Mex. Univ. Ann. Water Conf. Proc. 9: 18-25.
Discusses current research to improve yields of water from various forest types, and how land management changes to improve water yield may affect other forest uses.

Frutiger, Hans.*
Snow avalanches along Colorado mountain highways. U.S. Forest Serv. Res. Paper RM-7, 85 pp., illus.
Describes and illustrates 80 avalanches in four mountain pass areas and discusses possibilities for structural control.

Garcia, George, and Hickey, Wayne C., Jr.
Controlling cane cactus with 2,4-DP. U. S. Forest Serv. Res. Note RM-15, 2 pp., illus.
On a 400-acre test area sprayed just as new growth started, kill ranged from 95 to 100 percent. The herbicide, which must cover the plant completely, is equally effective as a mist or large-drop spray.

Glendening, George E., and Pase, C. P.
Effect of litter treatments on germination of species found under manzanita (Arctostaphylos). Jour. Range Mangt. 17: 265-266, illus.
More herbaceous plants emerged after complete litter removal than after burning, scarifying, or no treatment. Burning appeared to favor morningglory and yerba-santa. Required germination conditions for shrubs probably were not met in these laboratory tests.

Heede, Burchard H.
A pavement breaker attachment to drive steel fenceposts. Jour. Soil and Water Conserv. 19: 181-182, illus.
An attachment to a pavement breaker was designed and built to drive steel fenceposts perpendicular or at an angle into hard clayey soils during the construction of check dams. Application of this tool can reduce costs in gully control and general fencing jobs in areas with difficult access.

Hickey, Wayne C., Jr.
A device for cutting uniform inch-height segments of plants and plant parts. Jour. Range Mangt. 17: 154-155, illus.
Describes materials and construction of a plant cutter. This device eliminates the usual problems associated with the more commonly employed methods.

_____ and Dortignac, E. J.
An evaluation of soil ripping and soil pitting on runoff and erosion in the semiarid southwest. Internatl. Union Geodesy and Geophys., Internatl. Assoc. Sci. Hydrol., Land Erosion, Precipitations, Hydrometry, Soil Moisture Comm. Pub. 65, pp. 22-33, illus.
Soil ripping reduced surface runoff 96 percent and erosion 85 percent the first year; reductions were 85 percent and 31 percent, respectively, after 3 years. Surface pits were ineffective after 3 years. These mechanical treatments may have initiated or speeded up undesirable soil piping.

_____ and Garcia, George.
Changes in perennial grass cover following conversion from yearlong to summer-deferred grazing in west-central New Mexico. U. S. Forest Serv. Res. Note RM-33, 3 pp.
A 6-year comparison on semidesert watersheds showed that alkali sacaton, galleta, and blue grama declined under yearlong grazing but increased under summer-deferred grazing.

_____ and Garcia, George.
Range utilization patterns as affected by fencing and classes of livestock. U. S. Forest Serv. Res. Note RM-21, 8 pp., illus.
Utilization patterns on small watersheds grazed by yearling cattle were about the same before and after fencing. Yearling heifers gave more uniform utilization on rough terrain; mixed classes gave most uniform use when grazed on open range.

Horton, Jerome S.
Notes on the introduction of deciduous tamarisk. U. S. Forest Serv. Res. Note RM-16, 7 pp.
Describes the early introduction and spread of three tamarisk species. Records are taken from old nursery catalogs and herbarium specimens. Clarifies taxonomy of the species.

_____, Robinson, T. W.,* and McDonald, H. R.*
A guide for surveying phreatophyte vegetation. U. S. Dept. Agr. Agr. Handb. 266, 37 pp., illus.
Extent and nature of phreatophyte vegetation is essential when determining potential water savings. An economical, accurate 7-step procedure based on aerial photos and surveys combined with on-the-ground sampling is described.

Judson, Arthur.
Relative importance of weather factors creating slab avalanches in Colorado. West. Snow Conf. Proc. 32: 60-67, illus.
Wind has most influence on formation of direct-action slab avalanches in the high alpine zone. Combination of moderate winds, low temperatures, light precipitation cause avalanche risk to develop rapidly.

Lee, Richard.
Potential insolation as a topoclimatic characteristic of drainage basins. Internatl. Assoc. Sci. Hydrol. Bul. 9(1): 27-41.
A method is derived for characterizing drainage basins in terms of their "average" exposure and potential irradiation by the sun. There is a strong correlation between derived "radiation indexes" and evapotranspiration (precipitation-runoff difference).

Lillie, D. T.,* Glendening, George E., and Pase, C. P.
Sprout growth of shrub live oak as influenced by season of burning and chemical treatments. Jour. Range Mangt. 17: 69-72, illus.
Clipping and burning Quercus turbinella neither retarded nor stimulated sprout growth compared to clipping only. Spraying 4 pounds 2,4,5-T or 6 pounds 2,3,6-TBA per acre reduced sprout weight more than half after 14-1/2 months. Fall top removal retarded growth substantially more than spring. There was no consistent difference between chemicals.

Martinelli, M. Jr.
Watershed management in the Rocky Mountain alpine and subalpine zones. U. S. Forest Serv. Res. Note RM-36, 7 pp., illus.
Research in the subalpine zone is concerned with effects of vegetation on water yield; in the alpine, with aerodynamics of wind transport and deposition of snow. The goal is to increase late-summer streamflow--improve timing of water yield.

Pase, Charles P., and Pond, Floyd W.
Vegetation changes following the Mingus Mountain burn. U. S. Forest Serv. Res. Note 18, 8 pp., illus.
After wildfire, sprouting chaparral shrubs quickly regained dominance which had temporarily passed to herbaceous plants. Forb production reached a peak during the second and third postfire growing seasons and then declined rapidly. Buildup of grasses was slower, but by the sixth year all herbaceous cover was declining, while shrub cover and weight were still increasing.

Skau, C. M.
Interception, throughfall, and stemflow in Utah and alligator juniper cover types of northern Arizona. Forest Sci. 10: 283-287, illus.
The canopy camera provided the best index of canopy density. Interception was computed by subtracting stemflow (found to be negligible) and throughfall from gross precipitation. Throughfall was predicted with reasonable accuracy for either species by a regression equation.

_____
Soil water storage under natural and cleared stands of alligator and Utah juniper in northern Arizona. U. S. Forest Serv. Res. Note RM-24, 4 pp., illus.
Clearing may increase water available for forage production, but has little effect on water yields influenced by storage in the upper 24 inches. Stored water differs little between cleared and natural areas; much capacity remains unused year-round.

Tabler, R. D.
The root system of Artemisia tridentata on a high-elevation site in Wyoming. Ecology 45: 633-636, illus.
Reports that root configuration of big sagebrush appears to allow utilization of both surface and subsurface moisture and nutrients; results of study will aid in evaluating watershed value of this shrub.

Forest Economics Research

Caporaso, A. P.*
Forest area and timber volume in western South Dakota. U. S. Forest Serv. Res. Note INT-20, 4 pp.
Inventory of forests in western South Dakota completed in 1960 reveals 1.3 million acres of commercial forest land with 996 million cubic feet of merchantable wood. Ponderosa pine makes up 95 percent of total cubic volume; 83 percent of the timber is publicly owned.

Choate, Grover A.*
The forests of Wyoming. U. S. Forest Serv. Resource Bul. INT-2, 47 pp., illus.
Reports first complete inventory of Wyoming's forests on 4.9 million acres of commercial forest, three-fifths of which are sawtimber stands, mostly overmature. Of 22.6 billion board feet of sawtimber, more than one-third is spruce, one-fourth lodgepole pine.

Clary, Warren P.
A method for predicting potential herbage yield on the Beaver Creek pilot watersheds. In Forage plant physiology and soil-range relationships. Amer. Soc. Agron. ASA Spec. Pub. 5: 244-250.
Presents evidence that herbage production on sites cleared of timber can be predicted from surface soil texture and position on slope.

Love, L. D.
Summer recreational use of selected National Forest campgrounds in the central Rocky Mountains. U. S. Forest Serv. Res. Paper RM-5, 23 pp., illus.
Sites are described and observations summarized according to visitor's residence, equipment used, length of stay, age, and unit use. Factors associated with use, such as distances to fishing, drinking water, parking, toilets, other units, are measured.

Miller, Robert L.
Lumber production in Arizona and New Mexico, 1960. U. S. Forest Serv. Res. Note RM-29, 8 pp., illus.
Lumber production in Arizona and New Mexico has generally increased in recent years. Arizona sawmills turned out 329,859,000 board feet of lumber in 1960, nine-tenths of which was ponderosa pine. New Mexico's 1960 production was 227,773,000 board feet, with 89 percent of it in ponderosa pine, Douglas-fir, and Engelmann spruce. A shift to more production of Douglas-fir and other softwoods and less ponderosa pine is apparently due to more access roads.

_____ and Choate, Grover A.*
The Forest resource of Colorado. U. S. Forest Serv. Resource Bul., INT-3, 55 pp., illus.
Colorado's first complete forest inventory shows 12.3 million acres of commercial forest, 52.7 billion board feet in sawtimber trees. Timber cut in relation to inventory, however, is lowest of the Mountain States. Trends and future importance of other multiple-use forest values are examined.

Nardi, A. P.*
Colorado's forest area and timber volume. U. S. Forest Serv. Res. Note INT-10, 4 pp.
The 1959 forest inventory showed 12.3 million acres of commercial forest land, which supported 17.3 billion cubic feet of wood in sound live trees. National Forests administer 68 percent of the commercial forest land, 82 percent of sawtimber volume. Engelmann spruce is leading species in timber volume.

Tombaugh, Larry W., and Love, L. D.
Estimating number of visitors to National Forest campgrounds. U. S. Forest Serv. Res. Note RM-17, 4 pp.
Since every visitor to all areas cannot be counted, a reliable method of estimating use is needed for recreation research. Accuracy of recreation-guard counts and traffic-counter estimates can be improved through standardized procedures and use of prediction equations.

General

Price, Raymond.
The Rocky Mountain forest region--a challenge and opportunity for American foresters. Jour. Forestry 62: 622-626, illus.
An editorial-historical article on the multiple resources of a vast, rugged territory, and the challenges it presents American foresters who must make land-management decisions.

COMMON AND BOTANICAL NAMES OF PLANTS MENTIONED

Aspen, quaking	*Populus tremuloides* Michx.
Avens, alpine	*Geum rossii* (R. Br.) Ser.
Barley, Moravian	*Hordeum vulgare* L.
Bluegrasses	*Poa* spp.
Bluegrass, Kentucky	*Poa pratensis* L.
Bluegrass, Sherman big	*Poa ampla* Merr.
Ceanothus, desert	*Ceanothus greggii* A. Gray
Cercocarpus, birchleaf	*Cercocarpus betuloides* Nutt.
Chokecherry	*Prunus virginiana* L.
Clover, dwarf	*Trifolium nanum* Torr.
Clover, whiproot	*Trifolium dasyphyllum* Torr. & Gray
Cottonwoods	*Populus* spp.
Elm, Siberian	*Ulmus pumila* L.
Fir, subalpine	*Abies lasiocarpa* (Hook.) Nutt.
Fir, white	*Abies concolor* (Gord. & Glend.) Lindl.
Fescue, Arizona	*Festuca arizonica* Vasey
Fescue, Idaho	*Festuca idahoensis* Elmer
Fescue, sheep	*Festuca ovina* L.
Fescue, Thurber	*Festuca thurberi* Vasey
Grama, blue	*Bouteloua gracilis* (H.B.K.) Lag.
Junegrass, prairie	*Koeleria cristata* (L.) Pers.
Junipers	*Juniperus* spp.
Juniper, alligator	*Juniperus deppeana* Steud.
Lovegrass, Boer	*Eragrostis chloromelas* Steud.
Lovegrass, Lehmann	*Eragrostis lehmanniana* Nees
Lovegrass, weeping	*Eragrostis curvula* (Schrad.) Nees
Manzanita, pointleaf	*Arctostaphylos pungens* (H.B.K.)
Manzanita, Pringle	*Arctostaphylos pringlei* Parry
Mesquite, velvet	*Prosopis juliflora velutina* (Woot.) Sarg.
Mountainmahogany, true	*Cercocarpus montanus* Raf.
Muhly, mountain	*Muhlenbergia montana* (Nutt.) Hitchc.
Oak, Gambel	*Quercus gambelii* Nutt.
Oak, shrub live	*Quercus turbinella* Greene
Pine, Austrian	*Pinus nigra* Arnold
Pine, limber	*Pinus flexilis* James
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, Mexican white	*Pinus flexilis* var. *reflexa* Engelm.
Pine, pinyon	*Pinus edulis* Engelm.
Pine, ponderosa	*Pinus ponderosa* Laws.
Sagebrush, big	*Artemisia tridentata* Nutt.
Sedge, mat	*Carex elynoides* Holm
Sedge, needleleaf	*Carex obtusata* Lilj.
Sedge, Tolmie	*Carex tolmiei* Boott
Silktassel, Wright	*Garrya wrightii* Torr.
Spruce, Engelmann	*Picea engelmannii* Parry
Sweetpotato	*Ipomoea batatas*
Sycamores	*Platanus* spp.
Sycamore, Arizona	*Platanus wrightii* S. Wats.
Wheatgrass, crested	*Agropyron desertorum* (Fisch.) Schult.
Wildrye, Russian	*Elymus junceus* Fisch.
Willows	*Salix* spp.

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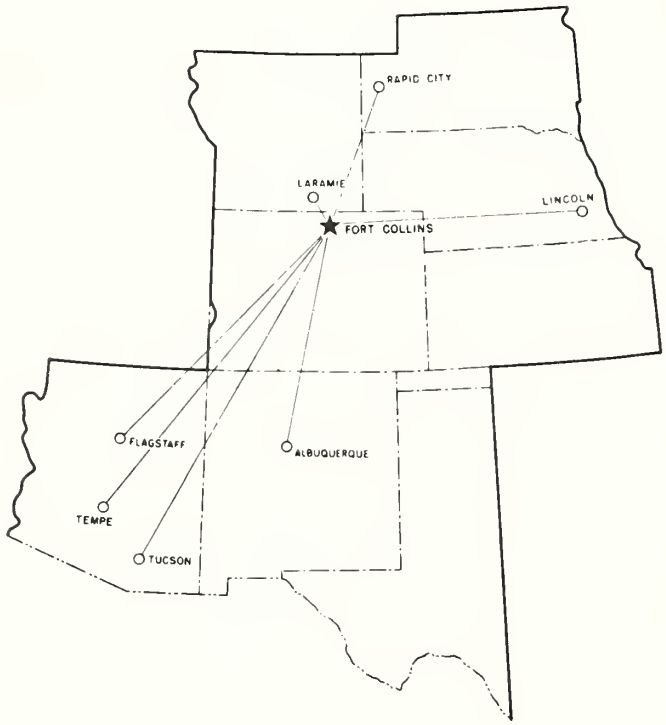
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